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Transcript of Proceedings

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS

Building Number 3
Goddard Space Flight Center
Greenbelt, Maryland

Wednesday, 29 October 1969

ACE - FEDERAL REPORTERS, INC

Official Reporters

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Washington, D C 20002

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(Code 202) 547-6222

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P R O C E E D I N G S

HALPERT: I would like to start off this morning by saying hello to you all, and introducing a man who needs no introduction, Tom Hennigan.

HENNIGAN: Well, I would like to welcome you to Goddard Space Flight Center again, and I hope that your visit will be both worthwhile and enjoyable.

This meeting will primarily be concerned with the discussion of the various sections of the interim model specifications for high reliability nickel-cadmium spacecraft cells.

The latest revision is dated April 30, 1969.

Also, on the last day of the meeting, there will be discussions of sealed silver cell specifications.

I would like to cover briefly the course of events that led to the writing of this nickel-cadmium specification. In the latter part of 1967 and 1968, Goddard personnel started to have considerable difficulties with sealed nicad cells. Abnormally high over-charge voltages and hydrogen evolution were indicative of the problems. Battery failures in the Crane test program and failure of the OAO battery during spacecraft integration resulted.

In our efforts to notify users that a serious problem probably existed, it was found that others were having similar or additional problems. A few small meetings were held with these people that were concerned.

At one of the meetings it was proposed that a symposium be held at Goddard with the main users of nicad batteries. Also it was requested that Gulton Industries attend this meeting. At that time the main concern was with the Gulton cells.

The meeting was held in October last year and involved about 30 organizations, both Government and industry. The problem areas were reviewed and such topics as plate quality, cell formation, negative to positive ratio, randomization of electrodes, non-woven separators, traceability of materials, and standard electrical tests were discussed.

During the meeting it developed that some type of materials control, process control, and uniform test procedures were required to avoid future problems, and to assure long life, high reliability, nicad cells.

This would apply also to other manufacturers.

As a result of the discussions and apparent requirements, several attendees were requested to serve on a working group to formulate a specification to spell out the desired design requirements, material and process controls, and test procedures during the fabrication process.

It was not the intent of the working group to specify how the cells were to be built. Also it was not possible in a reasonable time period to formulate a specification to encompass all nicad battery processes.

The writing of the specification was quite a difficult task. The working group members had not had a lot of actual battery experience in the actual making of cells. Their main experience was primarily as users.

Based on the various problem areas as each member saw them, a specification evolved, termed as a model specification, and a few areas may be somewhat idealistic. Basically it shows good judgment in material and process control. Some areas are considered critical, some may be considered as essential, and some as non-critical but good practice.

From the results of our discussions here in the next few days, it is hoped that in the next few months the specification can be improved and revised so that it will be generally acceptable to manufacturers and users.

Also it was not the intent of NASA and industry personnel to attach this interim spec to purchase requests, and require the battery industry to conform overnight. This would have been impossible. The spec was given wide distribution so that users could have a document from which they could excerpt information to be incorporated into their own specifications where they saw a need.

It has been noted that in several instances this has been the case.

It is my feeling that a uniform specification would be very useful in approaching standardization, and obtaining a basis for bidding on purchase requirements.

I would like to add that the work is proceeding to back up the control and test areas of the specification. Work on materials control is underway at Tyco. Separator screening and testing is being carried out by ESD Research. Recently this effort has been directed primarily towards non-woven materials.

Also a request for proposals is out to investigate process controls. Several in-house efforts are continuing.

Now the concept of this material and process control is not really new to the battery business. Over the last few years we have been using this type of specification to build silver-cadmium batteries. Previous to this type of spec or requirement it was very difficult to get flightworthy silcad cells. We would have trouble selecting cells, or entire lots would fail.

I would like to at this time introduce the members that are here, of the Committee.

Our Chairman and Coordinator was Mr. Billerbeck of COMSAT. We have Jerry Halpert, of Goddard, -- I just upgraded you -- Bob Steinhauer, of Hughes Aircraft, Will Scott, of TRW, Mr. Dunlop, of COMSAT, and Floyd Ford, of Goddard Space Flight Center.

I would like you to really appreciate what these fellows did on this spec, and in particular, the patience and coordination that Mr. Billerbeck showed during the specification writing.

Mr. Billerbeck would like to say a few words. Thank you for your attention.

BILLERBECK: I have just a very few words. I certainly would like to start off by thanking the members of the Committee who participated in helping to put this thing together so far, because quite a few of them did spend a lot of their own time, and quite a lot of travel time, in working on it.

Well, I would like to say we've heard considerable comment on the document so far, and some of it has been favorable. And so I guess today and tomorrow we give the battery companies their chance to see what inputs they'd like to put in at this time.

I think, as Tom said, the principal intent of this meeting is to move on from the original spec. I think we had sort of a consensus of aerospace users' inputs on the spec as it now stands. And I think the ground rules were that this is how they'd like to see a nicad cell built if they weren't particularly constrained by schedules or dollars.

So I think that these meetings now are directed toward making the spec more relevant. I think that's a popular word today. And so I think in some cases where we pin down specific materials, maybe it's pertinent to think about making those sections more general, or deleting them. But on the other hand, I think that the users in general, from my conversations with them, would like to retain many of the materials control and process control and end product tests, as they're called out here. But there certainly is some refinement in many of these areas that is needed, I'm sure.

I think that's important to all of us, because I feel that the spec as it is, as Tom mentioned, is being reflected in many procurements now to some extent. And the eventual spec will certainly be used more, by NASA and by COMSAT, and certainly I'm sure by other users.

As far as the Committee is concerned, in their participation here, we didn't line them up here as a shooting gallery so you people could shoot at them, but the principal role here today is to interpret the meaning of the existing spec, if there is some question about what was intended, as it stands.

And I think, then, beyond that, that perhaps the Committee will be involved in reviewing the spec as it evolves into the next phase here.

I also would like to ask Dr. Fleischer if he could sit up at the front table, since he was very instrumental in forming up this specification. So I'd like to ask him to come up front.

Now I'll turn the meeting back to Jerry Halpert.

HALPERT: I would like to make one statement, that I'm pleased to see all the cross-section of the battery people here at this meeting; users, manufacturers, and Government people, in hopes that we would come out with a meaningful and workable spec that we can all refer to.

Now at this point I'd like to describe how we would like to conduct this meeting. The procedure will be to talk about the spec only, that is to refer to the paragraph in the specification, in order, by number. The spec will be projected onto the screen. We have a projector here. So that you may not have to refer to your pages. It might be a lot easier for you.

Each man will be given five minutes to discuss the -- or make the statement that he would like to, about the particular aspects of the specification.

All the comments will be read into the minutes of the meeting, which is being recorded continuously here in front. We would like to request that no philosophy be presented. We all know that you have your own ideas of what a specification should be, and how it should be organized, the kinds of tests that should be run, the kinds of statements that should be in the spec. And at this particular point you can understand that this document was written by people who have some technical of the field, but not knowledge of writing specifications.

In time, the specification will be modified and updated, and will be prepared by the proper people, the specification-writing people and QC people, to be meaningful.

We would like your comments to support or criticize the specification. We have had a number of comments from the battery companies and others which we will read into the minutes as we talk about the specific paragraphs.

We have had a lot of criticism. We have also had some supporting comments. If you have a supporting comment about a particular test, it would help us to know that this is a meaningful test to you, so that we can make sure that we do include it in. I think if we were to take every test in there, we would have criticism about every one of them and we could throw out the whole thing to start with. So I think we want to go in a positive direction as well as continuing to make it a better specification.

We also request that you do not ask the people exactly why they put that comment in, or that particular test, into the specification. There may be reasons which cannot be discussed -- that is the philosophy behind it. We're trying to avoid philosophy here. If there is a question about the meaning of the statement -- in other words, does one mean you take 50 samples or 5,000 samples, the meaning of a particular statement, then this would be, certainly, in order to discuss.

Microphones are at the sides of the room. We have two for this particular section of the meeting. We're hoping to get a couple more. The microphones will have to be passed around amongst you as you decide that you would like to speak.

I will read the comments that we have about the specific paragraphs into the minutes, and then we will ask for comments from the floor.

Each speaker will be given, as I said, five minutes, and we have a warning system. We will be keeping time in case you kind of get long-winded. When the five minute mark is reached, you'll see an orange light at the side of the room shown, and if you continue on too much past that, you will see a red light. And I'd rather not tell you what that will do.

(Laughter.)

Are there any questions at this time about that procedure? For the reporter, please identify yourself clearly by your last name and the company, your affiliation. It will be taken down here. And we would appreciate anybody who has not signed in at the door on that attendance sheet, to please do so, so we have an accurate record of those who attended.

FORD: For the benefit of the people who might be planning to take notes, you might mention that everything will be recorded and copies will be available as previously, at the last meeting.

HALPERT: Okay. If we can project the first page up there . . .

(Slide.)

All right. I won't bother to read these off, because you can all read. I will only mention the comments that I have about the particular paragraphs.

I do have one about paragraph 1.2. It was suggested that a standard format be used, and he wanted to speak one minute on that subject. Where is Mr. Thierfelder?

THIERFELDER: My comment was that since we're attempting to standardize on battery specifications, we should not lose sight of standardizing on the specification itself. There is a MIL-STD-490 which spells out the breakdown of specifications. And I feel it would be a good idea to start right from the beginning and bring this specification into a format which has been used by the Government, and break it down into the standard sections of scope, documents, requirements, quality assurance provisions and so on, down the list. An attempt to do this later would only complicate matters.

HALPERT: Thank you. I have no other comments concerning 1.2 and 1.2.1 or 1.2.2. Does anybody have anything on those particular areas concerning military specs, federal specs or publications that should be included in this for reference?

Okay, if we can go on to the next . . .

(Slide.)

1.2.3, Definitions. I do have some comments about that. 1.2.3.1, the definition of Slurry specifically includes carboxy methyl cellulose. A general term such as "binder" should be substituted.

The definition of Plaque, by use of the word slurry, implies that a wet process must be used as a manufacturing procedure. Therefore, omit "slurry."

As written, "Formation" is described as the process prior to cell assembly when there may be several processes between formation and cell assembly. Therefore, "formation" should be described as a process prior to cell assembly.

I have no other comments on definitions. Is there anybody who would like to speak as to the definitions we used, or would like to add definitions to our list that appear in this document?

Don't be shy, now. We can use all the help we can get from you people who are the experts.

Okay, we'll go on to 1.2.4.

FORD: Jerry, may I make a suggestion for the benefit of the record?

HALPERT: Yes.

FORD: I have observed that you are reading several comments. Would you, for the benefit of the record, put the word "comment," then read -- put the word "comment" in front of each individual comment that you're reading.

HALPERT: Okay.

(Slide.)

All right. We have 1.2.4, Cell Marking.

I have a comment here that is marked 1.2.4 (d),

"It is recommended that the date of manufacture should be further defined as the date of activation of the cell by the addition of the electrolyte."

I have a comment about 1.2.5:

"It is assumed that alternate methods of such tests of procedures will be reasonable accepted and also that a manufacturing proprietary process is not subject to review. This question of proprietary processes is one which affects other industries and should be opened to serious consideration."

Any comments from the floor on 1.2.5?

(No response.)

All right. We go on to 1.2.6 -- I'm sorry, did I miss somebody?

GROSS: Sidney Gross, Boeing. 1.2.4 slipped past before I could get a comment in -- that the date of manufacture should be considered as the date at which the cell is sealed, that is, where the top is welded on. This will exclude the possibility of assembling a cell and then keeping it on the shelf for a year or two before you put the electrolyte in.

HALPERT: Okay.

All right, we finished 1.2.4. Any more comments on 1.2.4?

GASTON: Steve Gaston, Grumman. I think it might be helpful to add that the marking material used show that out-gas space conditions.

HALPERT: Okay.

UCHIYAMA: Uchiyama, JPL. My comment is again in relation to paragraph 1.2.4. It is in relation to the statement, "The serial number of each cell shall also be marked on top of the cell. . ." I suggest that the location of the serial number be left up to the user and the manufacturer, because very often in the design of the final battery, the position of the cell may very well be a very important factor, to where you may want to put the serial number for identification purposes.

HALPERT: That particular comment was in reference to 1.2.4.

Dr. Fleischer, did you want to say something?

FLEISCHER: Does everybody understand that if there are no comments on the statements that are made from the floor that they will be adopted? Did you make this clear?

HALPERT: No, I haven't made that clear, no. I would assume that the Committee, when there are no comments about a specific item in this specification, that the organization here -- you people who are the experts have agreed that this is a good idea and we'll accept it as such.

If you have a comment about it, it doesn't mean that that thing will not -- that it will be changed -- it could still go on to be the same comment, if the Committee feels such. But at least we will consider your recommendations about that aspect very strongly, very seriously.

BELOVE: Belove, of Sonotone. I understood from your first remarks, Jerry, that you were going to cut into the specification and reduce its rather voluminous nature. Now I think you should elaborate a bit more on that. That's why I thought nothing much was said here. It's as though we assumed that this would go into the record as the specification of the space batteries, as it sits, with minor modifications.

Now, from what you said at the very start when I came in, it almost indicated that this appeared to be too voluminous a specification, and that objections had been raised from manufacturing sources, and that you were then going to reduce the size of the specification. Is this or is it not so?

HALPERT: As far as I'm concerned, there is no criteria as to weight or size of the spec. This spec will be adopted, or at least parts of it, will be adopted as per your recommendations and the recommendations of the Committee. I've said nothing about reducing it; I've only said "upgrading it," to make the tests in here better suitable and more applicable to people who do it in the field. If they feel it is not an adequate test, please tell us -- that another test would be better.

This is what we're doing here. It has nothing to do with size or organization. We're not talking about organization now; we're going to do without philosophy.

BELOVE: No, no. I'm not speaking about philosophy. I'm speaking about actual, concrete -- the amount of testing that's implied and specified in this specification. I thought that you had implied that because people had objected to the size of this and the amount of testing, that you were going to reduce it.

I'm wrong. Thank you.

HALPERT: Okay. We have had our last comment on 1.2.4. Does anybody have anything to say about 1.2.4, 1.2.5, or 1.2.6?

I have a comment concerning paragraph 1.2.6:

"Considering the number of data sheets contained in the appendix of this document, a real cost impact is implied."

I have not identified the commenters here. If they would like to say something about their particular comment, I would welcome that very much.

RYDER: I am merely reminding the Chairman that he did not relate a comment on 1.2.5 which was submitted by Gulton. My name is Ryder, Gulton Industries.

HALPERT: I'm sorry, I think I did read that. Did I not read 1.2.5? I did read 1.2.5.

SCOTT: Scott, from TRW. Excuse me, Jerry. A point of, I guess, possible clarification of what I gather was Gulton's response to 1.2.5. I'm wondering if their comment is implying that they are saying that they reserve the right to withhold details of any alternate procedures submitted under the provisions of 1.2.5, if they consider them proprietary?

HALPERT: This is a question concerning the meaning of a statement, and I would request somebody from Gulton, if they would, to answer that so that we can clear the record, about the meaning of that statement. Would you care to make it, or would you like to put it in at some later time? I don't want to put you on the spot.

PREUSSE: Preusse, Gulton Industries. I think the statement is pretty clear. Again, when you start asking us for meanings of statements, it implies the same statement as needing some comments in the spec. Let's keep this open until later on, okay?

HALPERT: Fine. Let's go on, with a note that this is a comment that should be cleared up at some later date.

Now, we have cleared the 1.2 mark. We'd like to go on to the very next one.

(Slide.)

2.0. I have a comment from Mr. Reed of General Electric:

"Standardization of cell sizes necessary to implement detail cell spec." And he said he wanted to talk one or two minutes. Is he here today?

THIERFELDER: He's not here.

HALPERT: Did you want to say something about that?

THIERFELDER: No.

HALPERT: Okay. 2.1.1. I have a comment:

"We cannot use pure nickel strip in the present sintering equipment."

A second comment:

"Specification only describes the wet plaque procedure for making sintered plaques. Sonotone uses a dry powder method which has yielded successful, long-life satellite batteries and asks that this be included."

Mr. Belove wanted to say a few words about that.

BELOVE: Very few, Jerry. All of us know that there is more than one method, in fact, I know of two right now, of making plaques. The specification, however, appears to recognize only one method, the wet, slurry process.

It is our believe that the success of some of our batteries -- and one of them flying on Alouette and Isis -- would indicate that there was some merit to the dry process too. And so we recommend that the specification be altered so that the dry method for making plaques, as used by Sonotone and maybe some others, and which has produced excellent space cells, be included in the specification.

HALPERT: Okay, any other comments? I have one other comment on 2.1.1:

> "It is possible that evolution of hydrogen occurs at the edges of plates made with nickel-plated steel sheet. However, in our opinion, this situation creates less of a problem than the use of pure nickel as a support. The nickel band tends to deform during its pass through the sintering oven and consequently wrinkled bands and subsequently plates are obtained.
>
> "The use of screen as a support presents three disadvantages. The first concerns the head of the plaques which must be cleaned of active material by scraping or by compression of the sintering. This creates a weak section on the electrode. The second is that the screen

itself can be deformed quite easily compared to a metal sheet -- actually the edges become quite wrinkled. Thirdly, when the plaques are cut, there exists at the edges wires which can lead to short circuits."

Now, that's a particular comment about a process, and I'm not sure whether, after reading the second one here, that it's applicable to this meeting. The comment was with regard to a nickel-plated sheet being considered.

CARR: Earl Carr, of Eagle-Picher. Jerry, just one comment. Are we going to discuss the merits of the different processes, or are we going to discuss the different processes? I think we ought to all recognize that each process has its own unique advantages and problems. Eagle-Picher uses pure nickel screen, we use a dry sintering process, and we have a quite good space experience.

HALPERT: I apologize for that. I left myself quite vulnerable. I had read it, but that should not have been included in the minutes here.

All right, do you have any other comments about 2.1.1.1?

THIERFELDER: I have a question as to why the pure nickel is desirable?

HALPERT: Well, that's correct. I do not wish to discuss that at the present time. We would consider any other method, and I do not want to respond for the Committee here as to why a certain thing was chosen. If you do not like it, we will be very happy to have you take exception to it and consider that in the writing of the future spec.

I have a comment about 2.1.1.2:

"Record Hole Pattern. One spiral is 1,000 feet." It would take one hour and factory personnel, in addition to what they are presently using to perform that duty.

Another comment:

"We feel that this paragraph should read, 'The average size and number of perforations per square foot of sintered plaque area shall be recorded for each spiral or impregnation lot.'"

I have another comment:

"All meshed size should be included in this section. Also, specification should provide a specified number with an appropriate tolerance, which applies to the material in general, and not on a lot-to-lot basis."

Are there any other comments about 2.1.1.2?

We'll go on to 2.1.1.3. The following comments:

"It is difficult to obtain a thin nickel plating which can be controlled utilizing the ferroxyl test. On the other hand, if a thick deposit is made, such that the ferroxyl test is effective, the result is a lack of adherence of the plating as the band and plaques go through subsequent heat and mechanical stress during fabrication."

I have another comment:

"We use a test to control the nickel plating. However, there is not much point in going beyond this, since when the plate is cut bare iron is exposed on the edges as well as the impregnation attack on the plate."

Another comment:

"The question here is, if iron is not a desirable material in the cell, is the nickel-plating doing the required job, especially where nickel is attacked during impregnation process by the acidic nickel nitrate solution. Also, there is iron exposed when plates are die-cut to size. Therefore, the significance of this test is questioned if iron substrate is eventually exposed."

Any other questions about 2.1.1.3?

BELOVE: It is our opinion that the substrate should be pure nickel. One of the reasons -- and there may be others-- but one of the reasons that we see that in processing the iron may tend to corrode.

Now, whether this affects the performance of the cell or not, is not known for certain. However, we feel strongly that this is not the way to make a cell for satellite application, to have materials in it that may tend to corrode.

HALPERT: All right. Any other questions?

GASTON: Gaston, Grumman. I have a comment on the -- some manufacturers use an edge coating on the negative electrodes. We have examined this carefully and we have seen the edge coating does come off on sub cells. And it could possibly cause a failure mode.

So I'd like the Committee to consider the edge coating, and the adhesion of the edge coating in the specification.

HALPERT: Any other comments with regard to that statement?

Okay, we go on to 2.1.1.4:

"Prior to nickel plating the plate is degreased." That's the only comment I have. Are there any comments about that?

We go on to 2.1.1.1.2. Are there any comments about 2.1.1.1.1?

STEINHAUER: Steinhauer, Hughes. Could I make a general comment concerning these paragraphs that have recently been brought up? This specification, in a preface, we're shooting at a five-year or longer cell, and I think some of these more subtle effects may not be understood for five to ten-year missions; and what can be tolerable in a, say, one to three-year, or up to five-year mission, may be different than a longer mission. And therefore we should entertain comments on this long-life nicad.

HALPERT: Thank you.

GROSS: Gross, Boeing. On item 2.1.1.4, a statement should be included to the effect that the substrate should be cleaned, and should be clean, prior to impregnation. It may not be necessary to clean it with degreasing or other methods, but assurance should be attained, that it is clean.

HALPERT: Okay, we're down to 2.1.1.1.1. If there are no other comments about that, we'll go on to .2. I have the comment:

"Nickel Powder. This involves record keeping on a batch basis." And it would take 2.5 hours and additional factory personnel.

Another comment:

"Another important parameter is the bulk density of the nickel powder, since it affects compaction and therefore porosity and pore size distribution of the plaque. This is true whether wet or dry method for plaque manufacture is used."

Any other comments about that paragraph, .2?

CARR: Just one comment, Jerry, and that is that in places where we talk about a certified analysis, I just want to mention that that's a cost item, and it should be considered as such by the Committee. If they want 100 percent test, fine. It's just a cost item.

HALPERT: Any others about .2? Mr. Gross?

GROSS: Gross, Boeing. The items that are in the analysis should be specified. For example, particle size might be quite important.

KIRKENDALL: Kirkendall, COMSAT. I believe there's a need for clarification of the numbering of the paragraphs. In this 2.1.1.1.1, it implies it's a sub-category of 2.1.1.1.

BILLERBECK: Indeed. We have a numbering problem there. It should be 2.1.2 - Slurry.

HALPERT: Yes.

KIRKENDALL: Subsequently there will be a revision on all remaining numbers?

HALPERT: Okay, if there's no more about .2, we'll go on to .3, and hopefully we can pick up a little speed here.

Comment:

"This involves record keeping on a batch basis," which will take 2.5 hours and additional factory personnel.

Another comment:

"Rather than designate the binder as carboxy methyl cellulose, this should be left open and should be determined by the manufacturer of the cells. However, regardless of the binder, we are in agreement with the traceability which is called out."

Another comment:

"This paragraph is restrictive in that it specifies a particular binder or thickening agent, when general terminology should be used."

Any other comments about .4?

FLEISCHER: If we include the term "binder," instead of a specific material, we should add a definition for binder, so that it's understood exactly what its function is.

HALPERT: Any other comments about .4?

MAURER: Might I suggest that in the place of carboxy methyl cellulose, you just say "other slurry ingredient," and scratch out the next section, .4, so that you have all these factors on all the other ingredients besides nickel?

HALPERT: All right. We go on to .5.

Comment:

"This would add to the slurry cost."

Another comment:

"The measurements of pH can be inaccurate and misleading in mixed solutions, and therefore may not be a useful measurement, depending on slurry formulation."

Any other comments on .5? If I don't see you, please shout out, because it's kind of hard to see everybody out there.

All right, 2.1.1.1.6 -- I'm sorry, there's one on .5 I missed:

"The measurements called for should be made just prior to use."

Now we go on to .6.

"Record keeping and testing one hour per spiral. The continuous gas analysis impracticable, and we know of no equipment that can do it."

That's 2.1.1.1.6. Another comment:

"The measurement of the influent gas is more critical since it is the environment to which the plaque is exposed. The effluent gas is after the fact and is not an effective control point. Also, the furnace temperature profile should be measured prior to plaque sintering, since the temperature operation is both time a temperature-dependent."

Any other comments about .6? Yes, sir?

CARR: Just a definition, Jerry. Carr, Eagle-Picher. It says that the temperatures of the different chambers of the furnace should be monitored continuously. Does this mean a continuous recording type temperature device?

HALPERT: That's right. That's what it was intended for.

Okay, we're down to 2.1.1.1.7, rate of travel of substrate.

There was additional effort involved with rate of travel of substrate.

We'll go on to .8. Comment:

"Again the term spiral is used in this paragraph. We recommend that for this particular and all following cases whenever reference is made to a spiral, that in fact, either spiral or an impregnation lot should be called out."

Another comment:

"The term 'spiral' infers a given processing method, and should be given a more general term such as 'plaque lot.'"

Any others on .8?

Okay, go on to .9. Comment:

"We disagree with the necessity of recording coining pressure since the coined area thickness is a dimensioned thickness. This should be sufficient, as a control in defining the plates."

Another comment:

"Coining can be, and has been performed, after the formation process; independent of which method is used, the coined thickness should be monitored since it reflects directly the amount of compaction, i.e., percent reduction, that the sinter has undergone."

Another comment:

"If each size plate is coined, it will require a complete set of coining dies. It would eliminate the special capacities required by many customers. In many instances these special capacities are required for a weight reduction. It sounds impractical to us to make our standard cells because of the additional cost of the dies."

All right. Any other comments on .9?

2.1.1.1.10. Comment:

"This is unacceptable under the present process. We must compact in some cases."

Another comment:

"This paragraph is contrary to present practices, and we would prefer that a tolerance be placed on the amount of compactness rather than complete denial to the present method of production."

Any other comments about .10? Yes, sir?

THIERFELDER: Going back to .9, according to your definition of plates, that should be plaques -- in 2.1.1.1.9.

HALPERT: Yes. That should be plaques. Thank you. All right, do we have any more on .9 or .10? Any comments, questions? No questions. All right.

Going to the next, which is 2.1.2.1. I have a comment:

"Plaque Samples. We would lose 41 plates out of each 1000 feet, and it would require one man continuous."

Another comment:

"The measurement of plaque samples should occur at reasonable intervals to assure control of plaque uniformity. The samples should be taken at 25 foot intervals or every thirty minutes, whichever is smaller. Also, samples taken across the width of the plaque should be sufficient to assure uniformity of thickness and plaque weight. Samples should be taken across the plaque width in the quantity of one inch of sample per two inches of plaque width."

One more:

"It would be advantageous under our present method of production to take the plaque samples from the beginning, middle and end of an impregnation lot, after which the test recommended in 2.1.3 could be run."

BELOVE: Belove, Sonotone. Again, here is a possible advantage of the dry, slurry method, in that in the dry, slurry method, each and every plaque -- not pieces of it -- but each and every plaque is weighed, and can be weighed and all properties recorded.

HALPERT: Okay. I have a general comment concerning the next couple of paragraphs:

"In view of the plaque and plate sorting which we recommend in our discussion of paragraph 2.4, we do not think it is necessary to test as many samples per spiral as indicated in 2.1.2.1. This comment is primarily made regarding the porosity spectrum analysis because of its rather high cost. We believe that with the same lot of slurry, the same thickness and the same weight, which should be continuously controlled, the global porosity is constant and the distribution of pores does not vary a great deal. We recommend that this contention be verified in an initial qualification study (process qualification). Actually, we believe that during production, only one or two control samples per lot of slurry will be found necessary."

Any other comments about 2.1.2.1?

Okay, on we go. 2.1.3.2 is my next comment. Did anybody have anything before that? I guess there's nothing, really.

2.1.3.2 is the next one.

"41 samples per 1000 foot of spiral would be required."

Another comment:

"This frequency of measurement of porosity and pore size distribution should not be necessary if sintering furnace temperature and profile are stable. Thickness and weight per unit area measurement are normally sufficient if the temperature time cycle is predictable."

Any other comments about 2.1.3.2? Okay, we go on to 2.1.3.3. Comment:

"41 samples per 1000 foot of spiral would be required."

Another comment:

"In this case, the element to be analyzed for should be stated with the required accuracy and precision. Other methods for analysis are available and are easily handled by trained personnel. For example, induction furnace and absorption train."

Another comment:

"We have the same remark as above for the carbon content analysis. In production, one sample for each lot of slurry should be sufficient."

I have another one with regard to -- no, I'm sorry.

2.1.3.4 is the next. Anybody have anything on .3?

Okay. .4: Comment:

"It would be necessary to develop this test which does not"-- yes, I'm sorry. Go ahead.

CARR: This is regarding the carbon test on .3. Carr, Eagle-Picher.

We use a dry process also, and we don't feel that the tests on carbon are necessary in a dry process.

HALPERT: Going on to .4 -- anything else on .3?

2.1.3.4. Comment:

"It would be necessary to develop this test which does not presently exist at this company. The test which we use is quite different in that it measures the force necessary to push a needle through the plaque at one of the perforations in the band. However, because all results of sintering strength are in general quite dispersed, we believe it is a good idea to increase the tests so as to have a better average value."

Again, comment:

"41 samples per 1000 foot of spiral would be required."

Does anybody else have anything on 2.1.3.4?

STEINHAUER: Steinhauer, Hughes. If the spec is broadened to include the dry process, I think there should be applicable paragraphs as an alternative for slurry. In other words, there's nothing specifying a dry process and the controls that would be needed at this point for that.

HALPERT: Did you want to say something about --

BOGNER: Bogner, JPL. You're asking for a lot of measurements and requirements here. Do you have -- does anyone have any specifications to put on what these requirements should be? Maybe that's an approach to take.

HALPERT: I'm not going to answer the question. We will consider that, as far as the Committee is concerned.

Don, did you want to make a comment about mechanical--

VOICE: I just wondered if there was any question as to the -- relevant to doing strength tests and things like this. If there's no question about it, there's no need for me to make any comment.

While I'm talking, there is one thing between this general section and the next one. There doesn't seem to be any specification as to how the plaque should be stored, in what condition that should be kept. There is quite a bit on plate storage, but not on plaque storage, between sintering and impregnation.

HALPERT: Any other questions or comments on .4? Yes, sir?

GROSS: Gross, of Boeing. There's no criteria for success or failure.

HALPERT: Anybody else, on .4? Okay, I guess we'll go on to the next page. This is 2.2.1.2. Any comments on 2.2.1.1? All right, we'll go to .2:

"At the present time we use special controls for the impregnation of spirals for space plates; however, at the same time, in the same tank, we impregnate spirals for commercial use. Because of the size of the impregnation tanks, it would be necessary to have an order for space cells requiring some large number of meters of plaque in order to comply with this paragraph."

Any other comments on 2.2.1.2? Okay, we'll go on to 2.2.1.3. Comment:

"At the present time we take periodic samples during the number of cycles of impregnation, but not from each cycle as indicated. We question whether or wel 35

not the high expense for analyses is necessary."

All right, that's 2.2.1.3. Any other comments about that. That was .2.

2.2.1.3. Comment:

"Analyzing the impregnation bath would mean the 24 separate baths would have to be analyzed per spiral."

Another comment:

"The type and acceptable level of impurities should be stated. Also control levels and tolerance of pH on concentration should be stated. Density is not an accurate value for control of solution, and analytical techniques are available for bath control. Analysis of rinse bath is questioned since it is the end of a production stream and cannot be used as a control measurement."

Any other comments about .3? You all like it?

CARR: Carr, Eagle-Picher. We're just being quiet when we agree with some of the other people's comments.

On the impurities in the cobalt concentration in particular, we feel that this needs a better definition and it's certainly not the type of thing that we'd check each cycle. The other items, we generally check each cycle.

HALPERT: Any other comments? All right, we'll go on to .4. Comment:

"We do not use potassium hydroxide. This would require a complete new set up which we cannot make. The present process uses sodium hydroxide rather than potassium hydroxide and unless reason can be given for the change, exceptions are taken to this paragraph."

Another comment:

"We question the exclusive use of KOH processing of nickel-cadmium plates."

Any other comments about .4? I think there's a general opinion about that, isn't there?

Another comment:

"A precipitation solution of KOH has two disadvantages. First, the price of KOH is three times that of NaOH. Secondly, with present equipment, 4 impregnation tanks are supplied by a common reservoir that presently utilizes sodium hydroxide. To change to KOH for just space plates would be impractical. Separate impregnation equipment for space cells would have to be installed if KOH is definitely required.

"In the course of our studies for the development of space cells, we have conducted special tests to determine the effect of sodium hydroxide versus KOH as the precipitation solution. The results indicate no difference in the characteristics of the cells. Therefore, we recommend that the precipitation solution should be left optional as KOH or NaOH."

Any other comments?

FLEISCHER: I think at this point it isn't the potassium hydroxide or sodium hydroxide that is important, but the specification for it. In other words, you could use the crudest kind of sodium hydroxide if it isn't defined and included here.

HALPERT: Okay. Any other comments regarding .4? Yes, sir.

BELOVE: Belove, Sonotone. Dr. Fleischer brings up a point of impurities, and if I want to stretch a point here, I can say then why introduce any impurities into this, and let's go back to the wet slurry process. We're introducing carbon, we're introducing a carboxy methyl cellulose; let's give some thought to this. If we're going to keep it pure, let's give some thought to the other methods whereby this can be accomplished. Thank you.

RUBIN: Rubin, of Texas Instruments. After quite a bit of research we found out that the use of potassium hydroxide in the impregnation or formation procedures would essentially lower the coefficient of utilization of the nickel hydroxide. So therefore, it is unwise to use potassium hydroxide, and it's basically a chemistry effect. The sodium has to enter the lattice, and it has some substantial chemistry effects in it.

HALPERT: Any other comments regarding .4?

FLEISCHER: I'd just like to answer the statement before, by Lou Belove. I think the use of carboxy methyl cellulose or any other binder in the process should not be defined as an impurity, because if you do that then we have to look at the nitrate, which can be far more effective as an impurity if you leave it in, if your processing isn't correct.

So, in terms of impurity, we mean those things which are harmful to the operation of the cell. And I think we shouldn't get into a debate about this. The processing eliminates nitrate, and it will eliminate the carbon compounds that you use as binders, if you choose them properly and if you treat them properly.

HALPERT: Okay, thank you.

BELOVE: I don't agree here that this nitrate question isn't an important one. You say, yourself that nitrate may be an impurity. Now, carbon can also be a certain impurity. To this extent, all these extraneous materials can be considered undesirable. To the same extent that you want pure chemical solutions.

HALPERT: I'd like to cut off that type of comment, because that isn't at the moment helping the specification. I think we know what you intended, and I think we know what Dr. Fleischer intended. And the Committee will then utilize those statements to come up with something meaningful.

All right. Let's go on to 2.1. -- I'm sorry -- anybody else? Yes, sir. I'm sorry.

NIETZEL: Nietzel, T.I. I'd just like to make one statement about carbon content. I think you'll find that under the proper sintering conditions the carbon content of the resulting plaque will be lower than the carbon content of the material that went in. I'm talking about powder and screens.

FLEISCHER: I'll add a statement to that, just so that we're clear. Providing you do the sintering in hydrogen atmosphere.

NIETZEL: We do not use hydrogen.

FLEISCHER: And you can get the carbon down lower?

NIETZEL: That is correct.

HALPERT: Can we go on to 2.2.1.5? Is there any other comment about .4 now? Regarding the specification, please.

Okay, .5. Comment:

"Record keeping is all that is involved here."

Another comment:

"The stated method of control and measurement is inadequate. The number of impregnation cycles can vary appreciably, depending on the method of plaque manufacture, as well as the impregnation techniques. Therefore, the number of these cycles is of use for a given manufacturer and may not be readily compared to other processes. To determine the necessary attributes for controlling the impregnated plate, weight gain data is insufficient and misleading. This measurement in no way corrects for plaque corrosion which varies measureably between positive and negative plates,(and process to process) and in no way can measure the degree of plaque corrosion which affects the ultimate strength of the plate substrate. To determine the quantity of active material, present and converted and/or formed plates, precise analysis including one sinter weight per unit area before impregnation, substrate weight per unit area before impregnation, sinter weight per unit area after impregnation, plate weight per unit area after impregnation, quantity of nickel, cobalt, cadmium hydroxides and/or metals present, must be performed and documented. Using this type of analysis, actual active material measurements can be made."

Do you have any comments about .5?

GASTON: I think it is intended here in all the records which are being kept, that the day for the various processes and steps which are conducted, should be added. It isn't specifically called out. It might be of importance to know when each specific test was conducted.

HALPERT: Okay. Any other question about .5?

We'll go on to .6, then. Comment:

"We wash and dry the impregnated plaque while still in spiral form and not after being cut into plates."

Another comment:

"Drying in an inert atmosphere at less than 80°C. can be both costly and time-consuming. Since air is used at the present time, the reason for a change from air to the inert atmosphere should be substantiated."

Another comment:

"Not all processes dry plates between impregnation and formation. Therefore, drying should not be specified. Also, the pH of the rinse water as specified is lower than can be expected, based on solubility of both nickel hydroxide and cadmium hydroxide."

Any other comments about .6? Okay, we go on to 2.3.

I have a comment on 2.3.1:

"If a plastic material is used in the packaging of the plate material, it should be chosen carefully so as not to contain any contaminants."

Any other comments about .1?

CARR: Carr, Eagle-Picher. Have we established the absolute necessity for inert gas filled shipping containers, rather than a sealed container?

HALPERT: It hasn't been established, if that's what you're asking.

CARR: I think it ought to be considered by the Committee that inert gas filled containers is a cost item.

HALPERT: Okay, 2.3.4 -- we're down now to .5.

(Slide.)

Comment:

"Since considerable care is required in the packing and storing of plates, the six-month limit noted in this paragraph should be justified on a technical basis."

Any other comments about .5?

CARR: I didn't understand that. What was that again?

HALPERT: "Since considerable care is required in the packing and storing of plates, the six-month limit noted in this paragraph should be justified on a technical basis."

That's the comment to the Committee about this. Any other comments about .5?

CARR: I have a comment regarding 2.3.2. Do we have to use white gloves?

HALPERT: Okay, any other comments? All right, I think at this particular point we can all use a break, and I understand there is coffee waiting in the wings at the top of the stairs. So we'll return in 10 to 15 minutes.

(Recess.)

HALPERT: All right, gentlemen, first I think if there is no objection, we may do without this projection on the screen. You have a copy of the spec. Does anybody really object to not using the screen?

(No response.)

Secondly, I might say that the manner in which we're going through this is not specifically to keep it on a time basis. The time is not the important thing here, although we would like to keep it in a reasonable time limit.

The important thing here is to get comment -- receive comment from you, the experts, on how we can handle our process and specifications we're talking about.

I'm going to apologize here for a moment, because I've tended to cut some people off. I didn't really mean to do this. I'd like to stimulate the discussion, but keep it on a technical basis. If you have a good comment, please speak up. It would help us immensely. We're only eight people here, representing the whole industry, and you people, many of you, know quite a bit more about it than we do.

So if you can possibly help us, we're asking for your help. And don't be afraid to get up and say something. I'll try to go a little slower so it will give you the chance to think about it a little bit.

Thirdly, at the end of this particular session if we do have some time before lunch, I would like to possibly get into maybe a little bit of the philosophy or a little bit more of the background, if you care to make some general comments about. I think, hopefully, we'll have a little bit of time. If we don't have by the end of this session, we certainly hope to have by the end of the two-day session, to discuss this philosophy and the background and make some general comments about the whole thing.

So please don't hesitate, and I'll try not to cut you off. But please make the comments pertinent and to the general specification. At least the technical aspects of it.

Okay. We're down to 2.4. Plate Quality Tests.

My first comment is regarding 2.4.1.1:

"Although extreme care could be taken to prevent a rupture or cut to the storage containers, it is still possible for such to happen. It does seem, however, almost punitive to reject a group of plates because of the opening of their storage container. It would seem that subsequent tests would certainly determine whether these plates were in fact damaged."

Okay, is there a comment in that regard? At the sides of the room we have some people, Jim Stemmle and Ed Colston, who will be glad to pass the microphones in so you don't have to walk out to the edge.

MC CALLUM: McCallum, from Battelle. I wanted to comment on 2.4, where I see the word "quality" in there twice.

It's also back at the beginning of section 2.0. The name of this document has to do with the reliability, and I think both of those words either ought to be defined, or if they're synonymous, I would suggest that you eliminate the word "quality" and use the word "reliability," because reliability, I understand has a very precise meaning. Quality does not.

HALPERT: Okay, there was another one back in there somewhere?

CARR: Carr of Eagle-Picher. Regarding 2.4.1.1., I would think that MRB action would be appropriate for judgment of damage.

HALPERT: What was that? I'm sorry.

CARR: Materiel Review Board action.

HALPERT: Any other comments regarding this?

Okay. I have none on 2.4.1.2. Does anybody have anything on .2? Questions, comments?

(No response.)

Paragraph 2.4.1.3. Comment·

"Because of the requirements for visual defects or cracks, et cetera, shown in 2.4.2.2, it would seem that at least a double number of plates normally required would be necessary, and therefore, the sample size would have to be correspondingly increased."

Any comments on -- let's see -- I have one more on

BOGNER: Bogner, JPL. I'd say it would depend on the cell design, the number of sample plates.

VOICE: I believe that sampling inspection can't be used for these plates. With the long-life objectives, I think every care should be taken to assure that each of the plates used is at its best level of quality. And in order to achieve this, I recommend 100 percent inspection.

HALPERT: Any other comments about that? I might say one thing regarding this aspect. What we are trying to do here is set up a way in which we could inspect -- that is, take a sampling of the plates to see whether -- in other words, accept the plate batch lot; but that ultimately, all plates would be inspected.

In the next section -- section 5, I think it is, where we assemble the cells, that all the plates would be 100 percent inspected at that time. This would only accept the lot, and all the measurements would be made on that sample, the 80 or so that I give as an example in here. That is the purpose of this particular section, or what was intended.

CARR: Carr, Eagle-Picher. I agree, Jerry. I think there should be 100 percent inspection on plates, and I agree that there should be a sampling plan on plate lots. I think the sample size is somewhat excessive.

YERKES: Yerkes, Heliotek. I think maybe there's some confusion here --it might be on my part -- about the reference of this specification. It seems to me this is written for the customer, who is going to buy some plates or cells from somebody, and the manufacturer may want 100 percent inspection. But we don't want to compound this in any aerospace product -- it's a common problem -- it gets inspected, inspected, inspected.

So you may do 100 percent inspection, but then when you buy them off, there may be a sample which just keeps you honest. Is that the intent of this?

HALPERT: Right. The first, of course, for the plates, would be the sample of plates from that particular batch would be inspected to determine whether there is acceptability of the entire lot. If there were acceptability of the lot, then we would go downstream and when the cells were actually assembled, or put into a formation process, they would then be -- that is, every plate in the whole lot, not only the sampling procedure, but every plate in the whole lot -- would be accepted, to make sure that it would be adequate.

So -- is that what you're saying?

VOICE: The specification does not say that later on each of the plates will be inspected. In all of section 2.4 -- it begins with a discussion of sampling -- pardon me, 2.4 and some of the preceding sections -- talk only of sampling. There's no provision here, as I have the spec here, that provides for 100 percent inspection later on.

HALPERT: 7.2.2.4 would spell that out. And that will be discussed at a later time, when Floyd Ford, who wrote that particular section -- right here, all we're doing now is accepting the lots, really, based on a sample of the particular batch.

GROSS: Gross, Boeing. The need for the number of tests on samples should be determined by statistical means. In other words, if weights of plates, for example, are consistently well within the tolerances, then the statistical requirement for the number of samples to be weighed is less.

HALPERT: Any other comments regarding that particular aspect? Yes, sir.

BILLERBECK: I think that's a good general comment on the spec, that perhaps many of these tests should be done in the way that one normally does with these sampling tests. So that if you find a large percentage are not meeting the requirements, then you go to a larger sample size. And I think that would be a good way to arrange many of the tests in the specification.

HALPERT: I'll read an additional comment which I have here, which I missed at the time, which I think is directed at this:

"General comment on the sampling control procedure outline: We believe that without initial sorting of the plates, it would be impossible to meet the criteria of 2.4.2.6 (2.5 percent maximum reject). We recommend that a sorting procedure be included in which all the plates are examined from the standpoint of appearance, weight, and thickness. Those plates passing the requirements would then form the lot from which samples are taken. The inspection of the samples would then serve to verify that the sorting was well done. Relative to appearance, color standards are very difficult to establish because of the effect of age. This item, therefore, should be analyzed further.

I think this is a little bit further down. I think this regards this whole section. I'll just go on reading it, and then we can go on and cover the items one by one.

"Regarding visual defects, in our present procedures, which have less severe criteria for acceptance than this specification, a certain percent of the plates are rejected in sorting.

"Considering dimensions, our experience has shown that the standard distribution of thickness is in the order of greater than plus or minus 1 mil. The rejection rate will be extremely high. Finally, since the standard. . ." -- I'm sorry, cross out the word "extremely."

". . . would be high. Finally, since the standard distribution in weight is (a given figure) a tolerance of plus or minus 0.1 grams would result in a high rejection rate.

"The above comments are made to point out that from the standpoint of cost, the critical requirements of these paragraphs should be verified for necessity. Also, relative to the weight requirement, because of differing sizes of plates, we suggest that this limit be expressed as a percentage rather than as a fixed plus or minus 0.1 gram, regardless of size."

Those are some general comments about that whole section, 2.4, and I will now go to 2.4.2 if there are no further comments about that.

"Sample inspection should be carried out either before storage or on receipt.'

2.4.2.1. Comment:

"The establishment of color standards is rather unique in this business. Merely to reject plates because of variation in color, without determining whether it is a chemical or electrical performance problem, is to reject because of lack of knowledge rather than for real cause."

Okay, any comments with regard to 2.4.2.1?

FORD: Jerry, I'd like to ask a question in regard to the manufacturers' representatives here. Do any of the manufacturers at this time have any of their own color standards? Without elaborating on what they are -- a simple yes or no would be sufficient in this case. Have they adopted some type of color determination in screening plates for aerospace use?

(No response.)

I assume no answer will mean all of it is "no."

HALPERT: Okay, any other comments with regard to .1?

All right, we'll go to .2. Comment:

"The reject criteria shown in paragraph 7.2.2.4 seems extraordinarily tight. Can the limits set in this specification be technically justified? It must be remembered that the product is a sintered nickel product and not machined or honed."

Any other comments about .2?

We go on now to .3. Comment:

"The thickness tolerance of plus or minus 1 mil is technically unjustified and impractical. The same comments are for the length and width variation of plus or minus 5 mils."

Any other comments regarding .3?

2.4.2.4. Comment:

"The plate weight variations should be given as a function of plate area or plate weight."

Another comment:

"Variations in plate weight depend on plate size and should not be expressed in an absolute quantity. A standard deviation expressed as a percentage may be used. Also, the absolute value expressed here, .1 gram, is much too low and conflicts with the thickness tolerances allowed in 2.4.2.3, that is, a thickness variation of approximately 1/30th, while the weight variation is approximately 1/300th. So that there is an order of magnitude difference in the allowed variation."

I might just say that was a mistake, but most people did comment on that particular aspect -- that is, using a given value of .1 gram, rather than a percentage. And I'm glad that we were all awake to find that. That shows you're all doing your homework.

Does anybody want to comment now on any of that section up to 2.4.2.4?

Okay then, we go to .5 -- no, .6 is the next one. Any comments on .5?

All right, 2.4.2.6. Comment:

"Because of the limits set in this specification, we would prefer to run a 100 percent inspection on plates and reject those with defects. We do not agree to any total rejection of either a spiral or impregnation lot."

CARR: Which section are you on, Jerry?

HALPERT: 2.4.2 -- anywhere up to --

CARR: Well, regarding X-ray of plates, this is a tough procedure at best, and we don't do it on a 100 percent basis.

FORD: Does that imply you do it on a sample basis?

CARR: No.

(Laughter.)

HALPERT: I might make a comment about that. Although it says a 100 percent inspection -- 100 percent X-ray diffraction, in all of these cases we mean of a certain given sample, a fraction of a certain given sample, which is a sample in itself. But we don't expect everybody to take 1,000 plates, if that's the number involved, and X-ray them all to determine-- this is a -- in this particular section we've taken a sample from the original batch, divided that into certain parts, and of the certain parts we would ask for that -- suggest that that type of treatment be given. That is not a 100 percent inspection, and none of these represents a 100 percent inspection of every single plaque in -- plate in the batch.

BELOVE: Is it cause for rejection? And if so, what percentage?

HALPERT: We weren't going to bring up this point until later on, but as you notice in here, we have very few limits in terms of the actual processing. We do not know the limits. We are trying to find out what those limits should be. We are really asking for data at this particular time, to establish some ground rules so that we can say your particular process should be between these limits, and your particular process should be between those limits.

And we know if we get a batch that is not within those limits, that we know that something is wrong and we can reject.

At the moment we don't have those figures, so if you were to get a job today we could not reject it, based on that kind of number.

RICHARDSON: Richardson, Marshall. In regard to these breaks or cracks in these plates here, I think before you'd want to call out X-ray or radiographic inspection of any of these plates, I think first you've got to establish the criteria for the cracks. Can you stand a crack 100/1,000th long, you know, or is the crack completely across the plate? I don't know what benefit you'd get by just X-raying these sample plates. If you'd find cracks, how do you know that they're bad or good? How do you know whether they'd hurt you or not?

So, just to be radiographic plates, and for possible rejection of the sample lots -- I don't know. I think you need a study program or something like this, to determine what length of crack you can stand. Because I doubt if you'd ever find - - I don't know.

HALPERT: Actually, lengths of cracks are spelled out a little later on.

REED: Reed of Battelle. If I read this specification, 2.4.2.5 correctly, "the substrate for the sintered material" means the perforated foil. I wonder if this is the place to check it for cracks? Shouldn't this have been done way back before the slurry or dry powder was ever put on? And if this is done, do you really expect it to crack later on during the process? It might be possible that the sintered material cracks, but I question whether the foil would crack.

HALPERT: Good point. Any other comments regarding that?

All right. I have no other up through the end of 2.4.2.8. Does anybody have any comments regarding .5, .6, .7, or .8?

CARR: Again, Jerry, I think a materiel review board would be a thing to be considered before you reject an entire lot.

HALPERT: Would you describe what you mean by that, and how it would be -- would that be in a given company, or --

CARR: In producing quality batteries, our experience at Eagle-Picher is that we have, with certain customers, the material review board authority. And what this is that we have a board, a panel of people, representative of production, engineering, quality, the vendor representative of the company, and the government inspector where it's required on the contract. These people judge the defect and say that it can be used or it can't be used, and then determine corrective action.

VOICE: Earl, is this MIL SPEC-9858 a -- I think it is --

CARR: Probably is, but I'm not sure.

VOICE: I think we ought to institute that spec on setting up the quality.

CARR: MILSPEC Q-9858-A.

VOICE: It's a quality spec.

RICHARDSON: We prefer 200-3 or 200-2.

(Laughter.)

There might be some, just general.

NIETZEL: The MILSPEC does have it.

HALPERT: That is an area that we certainly could look into, and I think the specifications people will be -- it will be helpful in that area, to guide us, on which general specs and whether it be a NASA spec or a military spec or what have you. The military would like military specs and I'm sure NASA people like NASA specs.

GREEN: Green, Martin - Denver. On 2.4.2.5, I notice you're determining X-ray or radiographic techniques. Are we in a position with the state of the art at this time considering some of the success with infrared inspection, which is much more economical to determine the exact method in this spec at this time?

HALPERT: Well, I can say that 2.5 now, is for the substrate only. What we're trying to do is determine whether in processing the substrate has been cracked or broken or cut in any way. And this is a suggested means of doing it. And if you have others, certainly we would be interested in it.

GREEN: Well, my remark is based on the recent experience with solar cells where we determined cracks in soldering and so forth by the infrared method demonstrated pretty beautifully and now under investigation. And I can see the substrate material we're talking about being cracked and so forth in shipment from past experience -- undue jars and what not can sometimes cause these cracks. It may be that infrared would be a more economical way to show it up. That's my only point.

HALPERT: Thank you. Any other comments with regard to this particular section, down to 2.4.2.8?

Okay, we go on to 2.4.3, Sample Plate Electrical Formation Test.

Now, just in opening, I would say the same thing as I did before -- these are samples of the plates that we are talking about, that are samples from the given whole batch. These are not 100 percent of the plates in the batch -- only a sampling, which was spelled out in that MILSPEC 105-D.

All right, with regard to that, 2.4.3. Comment:

"Although we do not object to conducting the test outlined in this paragraph, we do question the value of running both plate formation pack tests and individual formation tests, since it would seem that the information from the former can be deduced from the information from the latter. Note also that we consider these tests as being extensive and expensive especially when performing a spectrographic analysis of twenty percent of both positive and negative plates of each sample group."

I have a comment from Mr. Herzlich of Marathon, and he wants to talk for about five minutes on this subject,

"To assure optimal reliability and overcharge capability, 100 percent testing of plates is desirable. In this way, individual plate capacities can be matched. The result is a uniformly high negative to positive capacity ratio."

Did you want to say any more than that?

HERZLICH: From your statement, I understand the scope is slightly different -- that this is simply an acceptance at that point, and although I can't find it, you seem to be saying that later in the spec each of the plates will be capacity-tested?

HALPERT: No.

HERZLICH: Then I'll reserve my comments to that portion of the spec where we talk about the capacity of plates, which I believe is later on.

HALPERT: Okay. We're talking -- the visual inspection, now, on this sampling, is only for the plate acceptance test. Later on, when we've put the plates -- use them in the cell, put them in the formation test, it's done on a batch basis, not on a plate basis.

HERZLICH: At that time I'll make my comments.

HALPERT: Okay, thank you. I have one more comment on 2.4.3 -- No, I guess that's a little later on.

Okay, let's ask for comments there, on 2.4.3, A. B. C.

(No response.)

Okay, 2.4.3.1, I have no comments on .1 or .2. Would anybody like to discuss .1 or suggest some changes to .1?

(No response.)

Does anyone want to say something good about it? Show their approval in some way? Some of these, as I mentioned before, we're looking for support in this matter, and not only are we trying not to make it tough on you; we're trying to be helpful. And we would like your help in this matter. We'd like some support on some of these items that we're talking about.

VOICE: That will, I think, be covered later, but I would like you to consider that an acceptance of the lot at this point may really not be necessary since you will be doing batch determination later on. So I would suggest that one of the considerations is that this test be omitted at this time, and be reserved for the evaluation of the batch.

BELOVE: Belove, Sonotone. Actually, this should be left to the discretion of the manufacturer. If he chooses to -- and he should -- sample before he does 100 percent testing. It obviously makes sense. But I don't think this has to be included in the spac, if you're going to do 100 percent testing later on.

HALPERT: I want to clear up that point. We're not doing 100 percent testing later on. We're doing 100 percent visual inspection later on. We are only doing testing by batch later on. There's no individual samples taken after this particular section.

BELOVE: This is our main point. We recommend 100 percent testing instead of batch testing, which we consider merely the use of averages. We think that averaging is not the way to attain the high reliability that is required in this product.

HALPERT: Yes, sir.

FORD: Jerry, to really clarify that point, I hope once and for all, this is a pre-production sampling that's being done, to accept the production run as flight-quality material.

In the inspection in production, that we'll get into later on, there is only a physical inspection, so to speak. There is no electrical testing on a 100 percent basis.

HERZLICH: Herzlich, Marathon Batteries. At that time we will make some recommendations about the 100 percent testing.

GASTON: Gaston, Grumman. Here it says counter electrodes for larger capacity, maybe an inert electrode can be considered, provided the electrolyte bath is large enough so that you don't change the concentration.

HALPERT: Which paragraph are you referring to now?

GASTON: 2.4.3.1.1, this counter electrodes of larger capacity.

HALPERT: Okay. Are there any comments at all with regard to .1.2 or .1.3?

SULKES: Sulkes, U. S. Army Electronics Command. The fact that you call out a special KOH formation, which doesn't really mean anything -- suppose someone just wants to use plain KOH, or doesn't want to soak them for that period of time? This would seem, you might say, to be a useless paragraph, in that it sets no requirement at all.

HALPERT: I think we spelled out somewhere about the KOH. I don't know where it's spelled out. Does anybody recognize where that was defined -- that specification?

BILLERBECK: Next paragraph.

HALPERT: Oh, is it? Yes. The special KOH solution is the next one.

BILLERBECK: It refers to 5.2.

HALPERT: Any other comments now with regard to .3 or .4?

REED: Reed, Battelle. This special KOH formation electrolyte, you've soaked the separator in it for 48 hours. It seems to me that this is a good source of impurities, if there are leachable organics in the separator, which you might want to eliminate. In fact, I think I might suggest that the formation electrolyte, both here and later on, be the same electrolyte in which the cells -- which will be placed in the cells. In other words, if you're going to put in an additive, you ought to also have the additive in the formation electrolyte.

HALPERT: I have a comment here that I missed, on 2.4.3. Comment:

"Although we do not object to conducting the test outlined in this paragraph, we do question the value of running both plate formation pack tests and individual formation tests, since it would seem that the information from the former can be deduced from the information from the latter."

I read that.

All right. 2.4.3.1.4., a question about --

"Soluble organics in formation electrolyte can contaminate electrodes." And that was Mike Reed.

Okay, fine. Okay, any other questions in regard to 2.4.3, down to .9? Any comments on .6? What we're essentially doing here is running a formation on a plaque and a plate basis, to get the variation within a group of plates, a sampling of a group of plates from a batch, to determine what the average is and how wide the variation is, and what we can expect in a formation pack that might contain up to 20 or 21 or 23 plates.

GASTON: General comment. I think it might be helpful to specify a temperature which the formation shall be conducted, and possibly a current density, so that eventually when more information is available, you will be able to collate all the information, and you might be able to come up with some tolerances, and specify what the limits should be.

HALPERT: Okay. I think the rate is spelled out in the paragraph before, that the rate for each sample plate shall be based on the current density used for a cell pack. So that we're essentially forming a plate.

Any other comments now down to .9? Okay, we go on to 2.4.3.2. Here we're running a second group of plates, in order to determine electrode capacities -- plate capacities. Any questions regarding that? .1 or .2? Yes, sir?

BELOVE: Belove, Sonotone. The same comment would appear to apply here -- that if, as we propose, 100 percent testing is instituted, then this is not required -- this testing, sample plate formation packs. In other words, again, we recommend 100 percent testing of the plates, rather than sample testing or 100 percent testing of the formation, or of the pack.

HALPERT: I might make one statement here about that. A lot of this was written based on prismatic cells, which of course, you now have 21 to 23 plates in an order of 100 cells, you can see we're talking about quite a number of plates -- thousands of plates. And it's difficult, and I think the manufacturers agree it's difficult to do it on a large lot like that, where you have many fewer plates, and you could do it in a cylindrical.

BELOVE: Jerry, I think you must agree to this: That if you're asking for a five or ten-year life and we don't really know what constitutes the makeup of the cell or the battery that will give us that, and you're trying to go -- what we're trying to do here is go mid-point. And what we're saying is you've got to go all the way. It's not sufficient to take half measures. Either take all measures or do as you have in the past -- sample the cells and try to test quality into them.

BILLERBECK: Billerbeck, COMSAT. I would like to make a general comment, since we're getting into a bit of philosophy here at the moment. And I think the purpose of this particular section -- maybe we could just enlarge on that for a moment -- was to attempt to determine whether the plates had the basic electrochemical properties that you need to build the cells, and that this be determined before production runs off a thousand plates and then comes back and tells engineering, "Well, gee. You know these are 10 percent low in capacity, but come on. We'll have to buy them off. We're committed now."

So the purpose is to determine before you get all the way down to the production process, that, gee, these plates really are capable of producing the capacity needed.

HALPERT: Okay, any other comments with regard to that?

NIETZEL: I think you forgot one of my comments, Jerry. And that was this: This procedure is only necessary, and I'm talking now about 2.4.3, all the way to 2.4.3.3.1 -- and that is that this procedure is only necessary when the plate manufacturing process does not normally produce data indicating that electrochemical capacities of both the negative and positive plates.

Also, the use of special separators and pre-soaking is restrictive in that other processes used today do not require these operations. Similarly, the use of pack formation is restrictive and is not required in all manufacturing procedures.

And I wondered if we are talking about 100 percent inspection, or are we talking about 100 percent sorting?

GROSS: One of the initial steps here is to perform the formation according to the manufacturer's procedure. Manufacturers can adopt formation procedures such that if at the end of the formation program the capacity of the cells is failing, or other bad features observed, they can add additional steps to -- additional formation steps -- which will try to salvage that batch, and increase -- bring the plates up to the requirements.

This should be excluded.

HALPERT: Any other comments with regard to this? Okay, we'll go on to 2.4.3.3. and .3.1 in which we're holding some of these sample plates up for physical and chemical analyses -- in 2.4.4 -- nothing unusual there.

All right. I have a comment with regard to 2.4.3 and 2.4.4.

"We believe, in view of the cost of these tests and analyses, that it be verified that all are actually required in the production of space cells. We recommend that all of these requirements be imposed on the manufacture of one lot in an effort to determine their relative importance on the characteristics of the final cell."

Any comments with regard to 2.4.4. or 2.4.4.1?

Okay, we go on to 2.4.4.2. Comment:

"The spectrographic determination of sulphur is not normally performed. Analysis for sulphur is more easily performed using an induction furnace absorption train and apparatus."

In all of these, now, we're making tests, physical and chemical measurements on these tests -- on these plates --

from the sample, and if you have some suggestions other than what are listed here, we certainly would appreciate hearing from you, on tests that you may do normally in-house that would be helpful in accepting or rejecting a plate lot, or in at least characterizing the materials.

All right, going on to 2.4.4.3 -- any comments?

2.4.4.4, Comment:

"The determination of negative plate porosity and pore size cannot be readily performed using mercury porosimeter techniques, due to amalgamation of cadmium metal which is present after formation. Other penetrating liquids would have to be used."

Anybody want to make a comment? Dr. Parry?

PARRY: I think there's a more fundamental objection to mercury porosimetry for determination of pore size distribution. All you really see is a breakthrough pressure, and it gives you nothing of the actual distribution that you have there. Metalographic techniques are far better in this respect.

HALPERT: You're talking about the plates now, as well as the plaques?

PARRY: Plates and plaques, yes.

HALPERT: Any other comments with regard to 2.4.4.3 and 2.4.4.4?

We go on to .5. Any comments with regard to .5?

(No response.)

HALPERT. .6? .6.1?

(No response.)

HALPERT: 2.4.4.6.2. I have a comment.

"In addition, the amount of cadmium metal must be determined for a complete analysis of the plates."

Any comments on .3 or .4?

PARRY: Parry, TYCO Labs. I think, going back to .6, the leaching out of active materials -- I don't know at the moment of an effective way of doing this for the positive plate. Almost all the methods that are looked at involve some dissolution of the substrate as well as of the porous nickel or the screen.

I think this should be taken into account in writing the specification.

HALPERT: Any other comments regarding this entire analysis of the plates? I assume you are all doing this and getting good results.

All right. We're at the end of section 2, and I think, according to our schedule we had planned to only go to section 2 by 12:15. The cafeteria is available to us at 12:15 -- that's the cafeteria across the way, Building 1. So we have about 40 minutes or so to talk about specifications in general philosophy. And I would just like to hear some general comments about the spec, how you think it should be put together, is it acceptable to you, would you accept the first two sections if you were given it tomorrow and told to build cells based on this spec?

Any general comments about it?

THIERFELDER. Thierfelder, G.E. Space Systems. Well, one general comment that I have is that I think the spec should be broken down into a cell spec, and an individual specification should be prepared for plates, separators, electrolytes -- you could probably limit it to those three -- but to put everything into one specification, you're covering one assembly and then several sub-assemblies. And I think it would be preferable to break it down into the components of the cell, specifications for those items. This is the way it's been done in many other battery specifications.

HALPERT: Would that mean that one specification is referenced --

THIERFELDER: That's right. In the cell spec we would call out the plates will meet specification so-and-so for plates, and the separators used in this cell shall meet the requirements of the specification (b), and the electrolyte used in this cell shall meet the specification (c).

CARR: Carr, Eagle-Picher. My feelings on this are that I think that the battery specification should be complete as possible in one document. I think, however, that if there are areas of work that are not done by the battery vendor, that they should be covered by a separate spec -- such as separators.

HALPERT: Any other comments regarding this?

MAURER: I have one additional comment, Jerry, over here. It was mentioned earlier that we have assumed a slurry type of plaque fabrication. There's also the possibility on the negative electrode of no sinter at all. This should be considered.

In the formation we have considered only electrochemical formation, and there are chemical formation procedures which should also be considered -- or at least not ruled out.

HALPERT: Okay, any other comments with regard to that?

MC CALLUM: Mc Callum, of Battelle. I was interested that almost any paragraph, you can determine a surface area pore size distribution or record the weight and thickness and there is no indication about what the numbers ought to be. And I wonder, where are those coming from? Are you going to furnish those later, who who is supposed to do that?

HALPERT: Well, this is supposed to be from a matter of experience. We hope, by putting in the spec the fact that these numbers should be measured, that although we can't hold you to any, we wouldn't expect to be able to hold you to any particular numbers or any particular limits -- that is, hold the manufacturers to any particular numbers or limits -- that ultimately we would have enough data compiled to know that a batch of cells should have these particular limits, and then be able to specify those later on.

Now this is certainly not a short time in coming. We don't expect this tomorrow or the next day. But there are a number of people working on evaluating materials in government agencies and under contract, and we hope that it won't be too long before we have some numbers that we can start applying to these various places in the spec.

GROSS: Gross, Boeing. A test should be added to determine the tendency of the active material to flake off the sinter. This probably can be done by an overcharge test.

LANDSMAN: Landsman, Lincoln Lab. If I'm not mistaken, we're in for some philosophy?

HALPERT: Yes. Speak your piece.

LANDSMAN: I think this specification is more than just a manufacturing specification for the manufacturers to do such and such. There was a comment about measuring effluent gases on drying, and that would not be used for process control. But I think this kind of information is the kind of information we want, because five years from now or ten years from now, it will possibly turn out that certain cells do last longer than other cells, and we would want to look back and see what is the difference, or where there any differences in the manufactur

And that's the thing we can't do now, because we do find some cells do last longer than others, and we don't know why.

HALPERT: I think that's the big problem -- we have nothing to refer back to. Changes are made from time to time to upgrade the product by manufacturers, and at that same time, really none of us know what the long-term effect is going to be. And I think that this spec really just gives us some numbers to hang our hats on a little bit later downstream, to see where we will be.

FORD: Jerry, I would like to make a comment to reemphasize what Mr. Landsman has said. I have had experience in talking with other people in other areas of aerospace products, that every test you conduct on a product isn't necessarily a "go, no-go" test. And this is especially true even at spacecraft level. You don't test the black box just to find out if you can go or no-go; you test to find out what characteristics it has.

And the purpose -- this is the purpose and the intent of a lot of these tests, to clarify the point that certainly in a lot of these areas there is no limit specified, for the simple fact that I don't think anyone here knows what the limits can be.

But after you have tested batteries for five years and you say, "They look great," and turn around and want to build the same battery again and find out you don't really know what went into that battery, you've got a difficult problem, because you'll build another battery and you'll want to say it's going to last five years, because I did it like this before. But what was before? We don't know that today. And until we take a more suble approach to this type of specification, we're not going to have the information necessary to reproduce high-quality products day after day, year after year, and decade after decade.

CORBETT: Corbett from Lockheed. I guess what Floyd just said kind of touches on something I was going to say. If I interpret things correctly, or if I interpret the intent of this meeting correctly, it is to kind of rigidize the processes that the vendors have now -- that is, we assume that someone has on the average a pretty decent nicad cell, and we're trying to specify the process enough so that it will continue to be the same.

But on the other hand, we have been buying batteries and cells in the past completely on a performance spec, and this performance spec has been more electrically-oriented than anything else. And very often it's been highly specific to the actual application of the spacecraft, and so forth.

But I would think, if not at this point, at least at some point, when we later get a better cell or a more reproducible cell, that we could get back to some sort of a performance spec. And I think I'd like to see some attention paid to the consideration of making tests on cells to determine if indeed they are what you expect a nicad cell to be -- things like overcharge tests, end of charge voltage tests, and things like this.

I think this is the more desirable approach, but the only problem now is that we don't know what a nicad cell is supposed to act like. And I think that's what is basically the problem.

BELOVE: Belove, Sonotone. There's one point. I don't know whether anybody has mentioned this in the past, we have a specification here and I think on the whole, I appreciate what is trying to be done and as a battery manufacturer I know why it's being done.

But I'm curious about something here. Many years ago when I first started working, I thought I knew all about electroplating, and so I specified to a plater exactly how to plate silver onto -- I think it was copper at the time -- and he followed my specs. And it didn't work out right. And when I brought it back to him and I said, "Well, you can redo this." He said, "I'm sorry, I followed your directions. It's yours."

And now I'm wondering, as a manufacturer, if I follow every step of these directions, and I make the product and it doesn't work out, whose product is it?

(Laughter.)

BILLERBECK: Well, I think there are several -- I believe Tom mentioned today, and I think I mentioned it too -- that there has been some realization by the Committee that we really don't want to rigidize the manufacturer's process. What we, I think, really are striving for here is to get testing during the manufacturing process that allows the manufacturer himself to know his process better and be able to reproduce it in the future.

And I think that's an important input here, that we -- and I think it has been brought out as we go along -- that we feel that there are some areas that need to be broadened to include more than one process.

We're looking for suggestions as we go along here, from each of you.

COHN: Cohn, NASA Headquarters. I didn't think it would be necessary, but maybe I'd better say so -- that we're not stopping R&D on nicads, because we think we have a final process. Originally I did not feel very happy about going into this kind of spec writing for just that reason, which apparently is bothering some people now.

But the point is, apparently we could not get the product we wanted without rigidizing the -- not necessarily the manufacturing procedures, but at least the characterization procedures. This does not mean that from time to time these specs can't be rewritten, as we learn more and as we get better products.

HALPERT: I think, in relation to this, I think what we're looking for is traceability as well, and recording of the data, so that we can use it for some basis later on. If we don't have this information, and we don't ask for it, we'll be in the same state as we are today, and as we were a number of years ago.

LANDSMAN: Landsman, MIT. I think an example of this -- I think it was mentioned last year at the meeting here -- had something to do with the amp hours of cells increasing with cells being made the same way over the years and people getting more ampere hours out of them. And somebody mentioned that they didn't change their process.

HENNIGAN: I think in this case, one of the problems we had last year --we have a gut feel that these plates were changing over the years. Somebody had been checking them, maybe we would have noticed a change and at least would have questioned it.

GROSS: The specification asks that a lot of data be taken to determine -- for traceability and for records. In addition to the data, it would be very useful to have -- to preserve samples of materials that are used from batches, so that specific tests at a future date can be conducted on the materials -- plates, plaques, separators, et cetera -- that went into the manufacture of the cells.

HALPERT: How about some comments from some of the other manufacturers here with regard to the spec? I think the users and the other government people would like to hear some comments, in general, from them. Is anybody interested in saying anything?

GASTON: Gaston, Grumman. I'm not a battery manufacturer, but I have a comment from what we have mentioned before.

We go and collect a lot of information, and I'm concerned about the data feedback. Each user will have various types of information based on his background, and of course various government agencies will have some information, depending on where the contract originated.

But is it possible to set up a central source where the information will be sent to, and eventually you might be able to have a much better picture, an overall picture, from everybody's experience? And then you can tighten the specification accordingly. I think it might be helpful if the information will be submitted to one specific source, where it can be analyzed and evaluated.

BILLERBECK: I guess we're looking to NASA Goddard as the center at the present time, or NASA in general.

STEMMLE: Stemmle, Goddard Space Flight Center. I have a small comment. It seems to me that the title of this spec is misleading. It's not necessarily specifying the product cell that is delivered, but the mass of information that you know about it.

But I think it's a good spec and worthwhile. It's a positive comment. But I think what it really amounts to is that the whole battery industry in this country is undertaking a vast research program in which all these parameters that we are specifying to the n'th degree are going to be studied, so that in the future, when a failure occurs, it just fits into part of the research program. You go back and perhaps trace it to a variation in some of the determined parameters.

FORD: Ford, NASA Goddard. This spec in the aerospace industry is not setting a precedent by any means. For example, I was cited the other day, in talking with project people about this type of spec, that in other areas -- and they gave me the example of a valve used in a spacecraft, a very critical valve -- it's a valve that you can go out in any store today and buy for $3.65. It cost $1700 -- to use in a spacecraft, the valve cost over $1700. And in itemizing the cost, comparing what the difference was between aerospace use and a commercial use, is the man-hours and materials that went into it. It was basically the same materials, but the tests that went into testing the basic material that went in the valve. And this valve is manufactured by one of the leading aerospace companies, incidentally.

So we're not setting a precedent in this spec. I think we may be setting a precedent, somewhat, in the battery industry, in looking at this concept.

BENE: I certainly hope that the ratio of the commercial valve cost to NASA's cost isn't reflected in batteries.

(Laughter.)

HALPERT: I think we're trying to look at it in terms of -- we expect higher costs; certainly the manufacturers have mentioned this, everything being cost impact on everything we want to do -- I think we're certainly willing to pay this higher price for a more reliable piece of equipment. And I think if we have the numbers and if we can control the tolerances and we can have a better feel that we're going to get reproducible materials, throughout a 22-cell pack, which is what we're looking for, then I think we can -- it will be well worth it to us. We won't have to go through some of the problems that we're going through now to qualify and requalify and choose materials by hand, without real good knowledge.

STEMMLE: It might be looked upon as a cheap way of doing research, really. We're going to have cells built for hardware, spacecraft, aircraft projects. And these are going to be useful cells. But at the same time they can be considered research things. And that can be compared with a research program of the size where you'd buy this many number of cells. I don't know in the next ten years how many cells are going to be bought, but if they were all bought for research purposes, with no other purpose in mind, it would be rather prohibitively expensive.

So it looks like a -- rather than making expensive cells, you're buying cheap research.

YERKES: Yerkes, Heliotek. I presume, since you are indicating you want to buy more paper, that you would just as soon get less pounds of batteries to sort of balance things out. And I know, from having seen a number of the labs that the users have set up, that the time and effort spent and wasted in combing through the product that's submitted, is certainly not cheap. And I would presume this is a reaction by the users of cells, and therefore it's something that obviously is going to have to be responded to in one form or another, and should result in less cells having to be purchased to do a given job in a given schedule. And the schedule, and the time lost in the schedules, to me seem to be something that are also very important in dollars that aren't counted in the hardware budget. You have lots of people at these companies who spend a lot of time trying to -- as somebody said earlier -- improve their cells by testing the hell out of them.

So I think this is probably a natural thing, and -- we manufacture solar cells. We go through this same sort of thing. And I think we're in the same situation. We start something like 20,000 solar cells a week right now, and some small percentage of them make it on to TRW or Hughes Spacecraft or some other -- Grumman spacecraft -- or whatever it might be.

And this same type of logic is applied here and in many other areas, and I think it's probably just coming to the battery people.

HALPERT: What we hope to avoid, I might add here, is actually not exactly testing hell out of it, or analyzing it after it's made, but trying to have some control in the beginning so you don't have to test the hell out of it later on to find out what you've got. Hopefully, you'll have some prediction of what you have, by knowing what you put into it.

CARR: Carr, Eagle-Picher. First, just our reaction to the spec, as Eagle-Picher, and that is that we certainly agree with the intent of the spec.

Second of all, in response to the gentleman behind me, these tests are going to take a much longer time to build cells for your spacecraft, and I wish that the prime contractors and the NASA contractors would take this into account.

GASTON: Gaston, Grumman. So far, we've only been talking about increase in costs for the application or the installation of this new specification. There might be some cost savings, too. I don't say the savings are going to be very considerable.

In the past we at Grumman had to do a very extensive cell selection for a specific flight battery. I have a little chart here which I had prepared and which certainly indicates with a partial installation of this new specification, you have much closer characteristics as far as capacities are concerned and as far as voltage spreads and overcharge are concerned.

If anybody cares, I'd like to show it on the wall.

I have three different batteries here. This battery was produced in September 1968, this one was produced in October 1968, this one was produced in October, 1969, just presently. And I compared the early cycle life capacity of cells made prior to selection. And these are 20 amp hours cells. And we found the early capacity spread from about 23.6 to 27.2 and 24.2 to 28.2, and now from 25.6 to .7.

Let me add, the last battery was a partial requirement or -- excuse me -- partial installation of making a requirement of the new aerospace specification. We couldn't install all of the requirements, because some were not practical because of schedule involvements.

And the overcharge voltage -- we overcharged these cells at three different temperatures. We charged at 40, 75 and 90. These are currents -- 1 amp, 1.6 amps and 2.3 amps. Again, you see the voltage difference, or the spread, has now narrowed down considerably.

So I believe with the closer controls of the details you can expect a closer control of characteristics, and eventually it will lead to a more reliable battery.

HALPERT: Any comments in regard to that?

THIERFELDER: Thierfelder, G.E. This is about something different -- I assume nobody had a question on that.

It has been mentioned that these cells we're talking about are high reliability for five years and up. Currently all the RFP's that I've seen recently for batteries required two years and less.

Is it expected we'll have two grades of cells or batteries, or is it expected on all the spacecraft that are two years and less, we'll use the same high quality reliability batteries as we're talking about here?

HALPERT: I guess that's up to the guy buying them. I would assume, from a personal way of thinking, I assume that once we have imposed the spec and once it is being used, a lot of these tests are going to be made a normal process, a lot of people are going to find that these tests are very good indications of what they're getting out of their own product. And they'll be using them anyway.

And I think you'll get a standard upgrading of all the products, including the commercial line, of all these materials.

THIERFELDER: Well, the question that comes up is that will we have to pay the cost of the five-year cell when we only need a two-year cell?

BILLERBECK: You could use the rejects, you know, for the --

(Laughter.)

FORD: Jerry, I'd like to make a comment along those lines.

First of all, I don't believe there's any such thing as two qualities for space use. There's only the best.

Second of all, most of your life requirements are put in by project people. If you have a two-year life requirement, that may even have been defined as far as Headquarters, to meet this mission success requirement.

However, nobody is going to complain if you come in and say your battery is going to last five years. I can assure you of that. In order to get these long-life requirements, we have to look at these higher controls.

The third point I'd like to make on this subject is that there is a definite trend in longer-lived spacecraft, particularly in the manned space station, where we're concerned with having to replace batteries on a shuttle-type operation.

So I think the day when we're talking about six-month batteries, one-year batteries -- and even to an extent, a two-year battery -- are pretty far behind us, and we're now talking about five to ten years life. Because the spacecraft are getting bigger, they're getting more expensive, as we all know, being aerospace contractors.

So you have to look at this in the light of what the anticipated need is in the next decade. And it certainly is two years and beyond.

STEINHAUER: Jerry, I'd like to comment. First, with regard to the Eagle-Picher comment on lead time, as Floyd points out, we are getting to longer and longer lifetime satellites. Although I have seen a plan proposed, if Apollo lands near Surveyor 3 that they might plug in a battery, we don't ordinarily count on that. And we're committed, once we put these batteries on the spacecraft. And perhaps a little longer lead time is going to have to be tolerated.

SULKES: Sulkes, Electronics Command. One question with regard to the spec, this doesn't appear to prohibit pre-qualification. In other words, a small order is being bought, but actually a large lot of plaque material could be pre-production qualified and kept available for future small orders; is this correct?

FORD: Yes, sir.

SULKES: So actually, some of the lead time could be taken up in that manner, by having qualified plaque material on hand.

CARR: Carr of Eagle-Picher. The spec says there's a six-month life on parts. So this is, right now, not practical. I think, however, one part of any work to be done in the future would be to consider how long is a plate good for, and what happens to it as a factor of storage, so that you can't use it.

We have definite feelings of our own about this.

In response to Bob Steinhauer's comment, all I really mean is that the Committee, in assessing how much testing should be done, I think that we should keep in mind the length of time that we're adding to producing batteries or cells.

GROSS: Gross, Boeing. In the course of the many inspections and tests, it will be found that some tests are really not adding very much to the quality. And the specification should be flexible enough so that expensive tests can be either deleted or shortened so that you could test them less frequently.

HALPERT: I think we're going to find that in some of these tests that they will be unnecessary. Once we're able to control and get some traceability on the product, when it gets downstream, I think we'll -- a lot of these tests will not be necessary. There will be one or two which we'll be able to spell out, where the problems really lie. And I don't think it's necessary to do all those.

What we're really looking for here are the optimum methods to look at these materials -- in this particular section, anyway -- to look at these materials in terms of what has happened back downstream, and how can we best assess what's happened. After that, other than just specifying the initial materials going into the thing, and having some normal controls that one would expect, the amount of testing I think will go down significantly, at least at some future time, when we have all the numbers.

MC CALLUM: Mc Callum of Battelle. Because we've just concluded a job to recommend accelerated life tests for NASA, I feel compelled to comment on this problem of semantics, and words we bandy around.

There are quite a few people talking about quality and reliability and traceability, and several people have commented it's clear to them what the intent of this specification is; and this is one of the things that confuses me -- what the intent of this spec is.

I gather it's an interim model specification for the data to be recorded in the manufacture of cells, and that there are not any specifications here on reliability, quality, or any other thing that we keep talking about. And somehow you've got to get that separated, or I know we've got a real problem.

HALPERT: Well, in answer to that I would say that what we require here is a specification at least of the number of samples that should be taken and the tests that should be made. Now what the numbers come out to be, and how we can reject them, is the thing that we're going to have to determine downstream. And that would be the basis for reliability in terms of a specification.

We can't really say right now what we can accept and what we can't accept. We have nothing to go by. But at least we can specify that at least this measurement should be made, and that measurement should be made, and in those terms it's a specification.

Now that may not be --

VOICE: Can't we change the title, then, to, "Specification for Amendments to be Made?'

(Laughter.)

HALPERT: The Committee will take that up.

RICHARDSON: Richardson from Marshall. When we first heard of the spec, I got a couple copies from old Tom over there, and we got a couple programs at Marshall there where we're using nicads, and in the ATM we attempted to impose the spec on a couple of battery primes, but the costs came back tremendously high. And as soon as the program manager saw the cost he said that's it, we can't have it. We can't stand the cost, and possibly schedule problems.

Has anybody here actually ever come up with an individual cost breakdown on a paragraph by paragraph basis, in the spec?

And you keep getting the wrong figures, you know, "X" number of dollars per cell, or on a contract basis it increased a million dollars, or something like this.

We're talking about cells that last a year or less for our programs -- for these ATM airlock modules.

And I don't know - - there is -- I guess most of the thing does call for generation of an extreme amount of data here which would be extremely good in evaluating, like you say, if you got downstream one year and you wound up with cell failures, you could go back, possibly, and pick up something in the data that you have which may lead you to the failure mode.

COHN: Cohn, NASA Headquarters. Would you care to comment on the ratio of price increase, roughly at least? 10 to 1, 100 to 1, 1,000 to 1?

RICHARDSON: I think it was -- one was about 5 to 1, something like that.

VOICE: Five to one was too expensive?

RICHARDSON: Yes. On the other one, I don't have any idea.

COHN: Too bad. It's ridiculous, absolutely ridiculous.

RICHARDSON: Well I agree with you, but when our program management sees this amount -- we're running on kind of an austere schedule and dollar-wise, and the program managers can't stand it. From a quality standpoint I think it's excellent. The spec is top drawer, let's do it.

BENE: A cost of five to one can kill any program.

VOICE: It's not ridiculous. What if he only needs a six-month battery? They do lots of things for 30 days. It's got to be a cost-effective criteria.

FLEISCHER: Will this gentleman from Marshall please state -- when you buy batteries, you buy how many, enough for one satellite? Or do you buy a certain number for testing and now what do you go through, and what does this cost you on your present procurement? Do you know these batteries are going to do what you want them for for one year?

It might be interesting to hear some of the details to set a background for why we need this spec, and why everybody is agreed that there has to be a specification; and a problem that comes in, as far as I can see, is what shall we put into it and how far do we have to go?

I think I've stated the two things that are behind writing this specification. In other words, when you buy your batteries now, how do you know you got what you specified? You want a battery that will perform for one year.

RICHARDSON: We have come up with what we call a minimum spec, or minimum quality spec, for the batteries, which encompasses like receiving inspections on critical items, review of the vendor's in-process specs, and so on, and specifying certain acceptance testing of cells if we're just buying cells from a supplier, or having one of our primes buying batteries or cells.

And then we have a section based on the acceptance testing of battery assemblies in that case, when we're buying the final batteries.

Hopefully-we at Marshall are building the CERM package for the ATM -- hopefully, we will run sufficient tests in the qualification area. We have several -- we have prototype vehicles -- I'm not sure of all the ones we have there, we'll be doing sufficient environmental testing on the testing vehicle, hopefully, to get us a good idea of how these batteries will perform in those areas, and through the qualification, and hopefully the implementation of the minimum quality spec, which will give us a good battery to last us the year that we want.

FLEISCHER: Well, actually, from what you have said, you're on your way to a specification of this type.

RICHARDSON: Yes, we have a specification which encompasses some of the items that you have in here also. But I can't say right now, today -- look ahead a year and say, "Yeah, that was great," or it didn't buy us a thing. But our program management kind of put the - - he said, "What are the minimum requirements that you, quality, can stand without the costs getting out of line?"

BILLERBECK: Billerbeck, COMSAT. I think a great deal of this depends too on whether the costs are in the original budget for the program. If you go by and try to retroactively introduce a factor of five increase in cost, that's a real problem; whereas if it's in the program from the start, then you have a little better situation.

RICHARDSON: That's true.

HALPERT: I think what we have to do is --

CORBETT: Corbett, from Lockheed. I have two comments. First of all, I think it's meaningless to talk about an "X"-year battery -- a five-year battery or a ten-year battery. And I think where this word comes from is because COMSAT or the Air Force or someone like that talks about a five or a seven or a ten-year spacecraft.

If you give me a battery that you quarantee to be a ten-year battery, I guarantee you I can make it last for only two years. Because everyone knows that the battery life depends upon the regimen that you put it through.

But I think what we're talking about here is a battery which can last for five years, and which will give reproducible results from month to montn, and from year to year on lot to lot.

All this testing goes for naught if you can't be sure after you've sampled the 1,000 cells and taken them down to Marshall to test them, that the next battery you buy is going to be a different animal.

The other comment was that -- on what Mr. Billerbeck said before -- concerning this business of the purpose of the spec. If you expect to get data on how to build a nicad cell, after implementation of this spec, or if the intent is indeed that the spec will generate some good data, I'd suggest that a more efficient way to go about that particular task is to sponsor work to determine what the battery should be, what are the optimum parameters. And then, perhaps, the spec is a more meaningful thing to implement at that point.

FORD: Jerry, I think, as a lot of people are aware, we are responding to that type of requirement. We have numbers in the spec at this time, in some cases. In some cases there are no numbers. And we realize that there is a lot of work -- one hell of a lot of work -- that has to be done to put parameters or limits on these numbers.

Therefore, no attempt has been made to do this at this time.

In regard to the gentleman from Marshall, I'd venture to say that had he showed the project management in the early stages the cost of testing his batteries, as compared to the cost of buying a high reliability part to start with, that the tradeoff would not have been too different.

And the third comment I would like to make, in regard to Mr. Gaston's statement, is about my estimate. My estimate is that about 50 to 60 percent of this spec has been included in the most recent OAO cell spec that he was explaining the data from. And you'll find out when you look at this, and really get down to the nitty gritty of the situation, it's not that hard to implement. It does cost more money. But in the long run, I think there may be a cost savings.

Consider the example, if I have to buy 150 cells to get 66 flight-quality cells, I feel that with the realization of a better quality control and implementing a spec, that may result from this, that the number of cells you have to buy initially will decrease, and most likely the rejects that the manufacturer had with his own facility is going to decrease.

HALPERT: Okay, if I may at this particular point -- we're getting into our lunch hour now -- I do want to make one comment.

Among our very distinguished guests here, we have some very special ones from our neighbors to the north, from Canada. I'd like to recognize Dr. Tom King, Sir George Mackie, and Mr. Stott, from the Defense Research Establishment, Ottawa, who have come down here and are helping us on an international relations arrangement, to get a better spec so that we all can work well together. We appreciate your coming down.

At this particular point then, being a little after 12:15, we will adjourn for lunch. We will be returning at 1:15.

(Whereupon, at 12:15 p.m., the meeting was recessed, to reconvene at 1:15 p.m.)

tape 1

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AFTERNOON SESSION

(1:35 p.m.)

HALPERT: Gentlemen, can we take our seats, please?

I would like to start this afternoon's meeting off by first making an apology to Dr. Tom King. I introduced him as Dr. Tom Scott before, so I thought I was cementing international relations and here I was cracking them wide open. I do apologize, Tom.

Secondly, we are going to skip over the separator section this afternoon and plan to start that first thing tomorrow morning.

We have two gentlemen who are very much interested in being here for the separator part and they could not be here this afternoon. So we are going to skip by 3 and we are going to skip by 4 until 3:00 o'clock this afternoon and we are going to go directly to 5 at this moment which is really dealing with the basic material.

Okay, let's start off with Section 5 which deals with the water and the electrolyte, and we see here in 5.0 and 5.1 and 5.1.1 we talk about deionized water and how it is -- what resistance it should have. The resistivity of the water shall be no less than .5 megohms. To increase this level to 1.0 megohms requires removal of an additional .5 ppm. In light of other impurities present in the process, i.e., 10 ppm carbonate in the electrolyte, 1 ppm nitrate in electrolyte and approximately 1000 ppm chloride ion in the separator, this level of purity in the process, water becomes by proportion insignificant.

I wonder if anybody had a comment about water in the conductivity of water.

Yes?

CARR: I think maybe instead of saying deionized water, leaving you kind of open, I think maybe we ought to be talking about again limits regarding maybe this can be determined by the committee from some of the work that has been done on impurity studies.

HALPERT: Any other comments regarding this?

CORBETT: This is kind of a small comment, but I think there are probably better ways of measuring conductivity of water to determine its purity, and with a cell that from what I can see is the type that is normally used for highly conductive eletrolytes, it is down in the conductivity range of potassium chloride, and with a standard bridge, when you get up around -- if the bridge is designed to measure solutions on the order of this conductivity, when you are measuring things that are in fact up around megohms the results are very poor. So you might want to have a special cell or perhaps an electrolys method to determine the purity of the water.

HALPERT: Is there another comment about that? Do you think the electrolys method would be as accurate as using conductivity cell? I don't know.

CORBETT: I don't know, but I think it could be designed for that application.

FLEISCHER: I think that one of the things that has been missed in this is that you cannot measure the conductivity of certain organic compounds like sugars and related compounds that might be in the water, especially in the fall of the year when the water is coming off of old leaves and fallen leaves and dried leaves, so that you might be using water that is very impure with respect to ultimate formation of carbonate or of materials that can affect the eletrodes.

HALPERT: Is your suggestion to --

FLEISCHER: We will have to add something to allow for residual matter in the water.

BENT: 5.1.6.

HALPERT: Any comments about .5 megohms with respect to 1 megohm? Does anybody have any strong feeling one way or the other that it is difficult to get .5 megohm, difficult to get 1 megohm?

(No response.)

HALPERT: Okay, 5.1.2 where we talk about the resistivity, 5.1.3. I think the intent of 5.1.3 was to have some standardized method or some standardized cell for measuring so you don't keep measuring with the same cell and then find out downstream that that cell was actually reading incorrect and you find a way of standardizing it. And any other way, if there are any other methods, that certainly would be reasonable.

5.1.4.

REED: Just a little point on 5.1.3. You have listed here the conductivity of 1410 plus or minus 20 micromhos, should be micromho centimeters at 25 C for 10th molar KCL. According to the handbook the conductivity of 10th molar KCL is 12,880 and this is the conductivity of 100th molar, so you might want to correct that for standardization purposes.

HALPERT: I have a comment regarding the same thing. The value of the concentration is an error and the value of specific conductance is in error. And the correct numbers are listed.

Okay. I am sure that will be corrected.

5.1.4 which deals with the silica content in the water. A comment regarding whether this is -- need a definition as to whether it is a silica, silicates, silicone or silicone as silicates, and I am not myself certain at this moment what is intended as that silica content. Maybe somebody has some comment about the silica content. We know that we had some trouble, and barring the fact that -- we are talking about separators today, we know that the separator can be a source of silica based on the way it is processed, so

I wonder if anybody else has a comment regarding silica or silicon or silicates.

(No response.)

HALPERT: I trust by your quietness that you think it all ought to be removed; is that right? Anybody see any need for it?

HENNIGAN: I just recently saw a patent where silicates did improve battery performance. They didn't say how much. One of these paper patents again.

(Laughter.)

HALPERT: Okay. 5.1.5, I don't have a comment on that one.

5.1.5 dealing with the solids content of the water and the total organic materials. What we are essentially doing in this whole section is just specifying what we mean by deionized water. Is there any comment other than these about the deionized water?

NIETZEL: A comment about organic matter. I think you may want a spec relating to color. That would help solve that problem.

FLEISCHER: It might.

HALPERT: Okay. We go to the electrolyte area, 5.2.

FLEISCHER: I would like to make a comment about this, the association of official agricultural chemists have standards for methods of determination of all the constituents in water, and I think all we need to do is pick out the items we apply and say this is the specification that we shall use. It gives the limits and also gives the methods of determination, and they keep them up to date. They are constantly revising them so they are up to date. So I don't think this should be done any other way than to accept what is known by the association.

PREUSSF: I think you forgot to read our comments on 5.1.6.

HALPERT: Yes. Right. I had forgotten that. 5.1.6. Since the solid content of the water is in the range of 10 to 20 ppm extraction of organics from this small amount of solid residue wouldr equire an initial quantity of water which would be extremely large.

Did you want to make any comment other than that?

PREUSSF: No.

HALPERT: Okay. Now we all know what water is and how we are going to use it. We will go on to the electrolyte and see how we can dilute it.

5.2, 5.2.1 are pretty straightforward. That should be available from the manufacturer.

5.2.2. I have comments. Electrolyte concentration can and should be held to plus or minus .25 percent. There is a limit that we can look to as a number.

5.2.2. Another comment. This will require a different procedure from that presently used. It would mean that the electrolyte would have to be bought in 55 gallon drums. The cost I am sure would go up over the present carload lots. I don't think I understand that. Does that mean a mercury cell grade is not available in carload lots?

FLEISCHER: It is available in truck lots and tank car lots.

HALPERT: Okay.

NIETZEL: Truck lots run 2000 gallons.

HALPERT: Okay. Another comment. Either deionized or distilled water should be permitted for mixture of electrolyte.

Anything else? Anything else on the mixture or the tolerances?

(No response.)

HALPERT: Okay. 5.2.3. A comment from Mr. Reed on the data showing the carbonate concentration is .01 grams per liter and less than that is normally obtained by the method described.

Dr. Reed, do you want to talk about that?

REED: Just briefly. We have made ordinary laboratory measures using the deionized water diluting 45 percent koh down and we got in the order of 2, 3, possibly 4 grams of potassium carbonate per liter. I made some other with a little more care using distilled water, triple-distilled from alkaline permanganate under nitrogen and get down around .2 or .3 of a gram per liter, and when you get down this far I think it is very difficult to determine the amount of carbonate by this method, the double titration method, because the amount of acid required to go from the phenolphthalein to the methyl purple end point is very small unless your acid concentration is very low. And meanwhile if you are using low acid concentration you are using a very large quantity of acid to titrate the koh. I think we are perhaps putting the carbonate concentration lower than is either necessary or reasonable.

HALPERT: Do you have a method which you would suggest that we could use?

REED: No. I think the method is good but not for determining this low a concentration. In other words, if we are talking of the order of somewhere between .5 and 3 or 4 grams per liter, then the method is quite good and the accuracy should be sufficient.

HALPERT: Okay. I have another comment with regard to that. The specified carbonate concentration interpreted as grams of carbonate as CO_3 minus the carbonate ion exceeded the level presently supplied as mercury cell grade koh. The level of carbonate ion can be as high as .03 percent as potassium carbonate or as 45 percent koh, if I interpret this correctly, to be approximately .2 grams of carbonate per liter. By diluting to 30 percent this value does not decrease to the requested .01 grams per liter and is more in the order of .01 mohls per liter.

DUNLOP: I have got a comment. Two comments, really. One is that if you put any additives in your electrolyte then you have to change this procedure slightly or do something else to determine how it affects what you determine by the titration.

Secondly, we did some work with W. R. Grace and I think we have a method to become slightly more accurate in the carbonate by the double titration. I don't want to describe that right now, but I would like to propose it to you and show you what we did there. I think it is a little more accurate way to do it.

HALPERT: Any other comments with regard to 5.2.4? 5.2.3?

FLEISCHER: Before you go on, maybe we can call Tommy King to tell us what they use because they have been through this problem so exhaustively.

KING: Well, as far as the carbonate is concerned, we have been working on that problem since about 1952 and have reached this conclusion, that for any battery to give good performance it should be quite low, and for all our cells we are calling up less than 4 percent.

Now, the titration method we use is the double end point as referred to earlier and this has proven out quite satisfactorily. However, there are interpretations of how it should be done and I wouldn't like to get into that discussion just now, but we have had good success with it and we can detect pretty accurately our carbonates two ways. One is by the performance of the battery, by its voltage, and the other is confirming it by the analytical method.

DUNLOP: Right. We did the same thing. It worked very well.

HALPERT: Is there a limit that you use?

KING: Less than 4 percent or lower. The lower it is the better it is.

FLEISHER: That is 4 percent by weight so you have a density of 1.3.

KING: Beg your pardon?

FLEISCHER: The density of 30 percent --

KING: That is right. Less than 4 percent by weight or less than 2 equipments. Two equipment percent I should say. That is what we aim for, and for any of our batteries, regardless of what they are, we call for that and one of the reasons is that if we get above that we don't meet our low temperature environmental requirements that we need in Canada. I am talking about all batteries, aircraft, et cetera, as well as spacecraft.

HALPERT: Thank you.

Is there something else?

SULKES: It would appear that the .01 is so far out of line with -- let's see, he would have -- Dr. King -- 50 grams per liter of carbonate.

FLEISCHER: Fifteen.

SULKES: Fifteen. And also the volts you would get even on the normal handling, perhaps you are about 2 orders of magnitude out than what you are really asking for.

STEMMLE: A comment here. This past summer I was doing some reading in Pierce, Haynes and Sawyer's biometric analysis book and one of the ways that they suggest to make carbonate-free alkaline solutions is to start with concentrated sodium hydroxide. Apparently this biometrically analytically removes all the carbonate. So my question here, which may not be appropriate, but would it be possible to arrive at a carbonate-free eletrolyte by mixing in a small fraction of sodium hydroxide?

REED: The clue here, of course, is that sodium carbonate is quite insoluble in sodium hydroxide, but the case is not similar with potassium carbonate and potassium hydroxide. You have a very high solubility of potassium carbonate in potassium hydroxide. The only way I know of to get rid of it if you have it in is to precipitate it with barium hydroxide and you may not want to add the barium ion to your electrolyte.

STEMMLE: Well, my question would be is sodium carbonate soluble in potassium hydroxide? It may be that it is not and you could get rid of the carbonate this way.

HALPERT: All right, we go on to 4.2.4. The comment I have, are these specific ion electrodes commercially available and are they effective in concentrated alkaline solutions?

I can say that the nitrate one is available and the chloride one is available. We have not finished enough test methods to know whether they are active or whether they will work in a high concentration of alkaline.

Some information. There is some test data on these specific ion electrodes. Do we have anybody here who might be able to comment on that?

GASTON: I have been informed that the ions electrical electrode does not perform too well in a high concentration and so we chose a colormetric analysis instead. I don't have all the details to actually answer your question.

HALPERT: Does anybody have anything else now on the 5.2 series on eletrolyte or the water content? Any comments? Any comments regarding this?

(No response.)

HALPERT: Okay. Going to No. 6 which is the metal container. In Section 6 I have a comment. We presently use neither stainless steel nor pure nickel. Stainless steel presents a danger to the electrolyte for a potential exists chrome will pass into the solution. For cells with 12 amp hours and above we utilize nickel-plated stainless steel containers which are formed by a press and have no welded seams.

Another comment regarding Paragraph 6.1. 304 stainless steel should be permitted as well as 304L stainless steel.

A comment regarding 6.0 or 6.1 which regards the material. Anybody have any information with regard to 304L or 304?

CARR: We use stainless steel drawn cans in our space batteries and we have had quite good success. We are using the 300 series. I think maybe this ought to be broadened. We are using actually 305. Exactly why I don't know, but we are.

ALPERT: Any other comments with regard to that?

Yes, sir?

CORBETT: I have a question as to why in the early part of the spec, which I did not comment on at that time, why nickel is the preferred material and why stainless is not the preferred material for plating and if so, why should it be different for the case material, especially if you are using a third electrode which is in common with the case?

SCOTT: A practical question regarding 304 versus 304L. We note that 304 is available in stock at the mills in the gauges that are now being used for making cell cases whereas 304L is not and requires special mill runs and therefore there is a definite problem of scheduling and availability for 304L that does not exist for 304.

HALPERT: Can I ask, Will, if you know whether there will be a problem with dimensions, with handling of the 304L versus the 304, if they had to make special mill runs? Do you have any feeling for that?

SCOTT: Do you mean maintain dimensional tolerances on the special runs?

HALPERT: Yes, right.

SCOTT: I can't comment on that. I am not aware of any problems that have come up.

HALPERT: As I understand -- to clarify for those who don't know the difference, it is mainly in the carbon content. I think it is -- no, I don't know the tolerances right now. 304L being a lower -- being lower in carbon content than the 304.

FLEISCHER: Does it have columbium in it?

CARR: That is 3.2.1, Art.

HALPERT: Does columbium present a problem that you know about?

FLEISCHER: No, no. It is usually put into the welding rods, in gas welding, so that you don't have carbide precipitation and that is why you want the low carbon. If you have carbide precipitation with stainless steel welding you have corrosion problems.

SCOTT: I am not convinced that there may not be a number of other alloys in this series that are suitable for this use. I am not sure why just the 304 and 304L are the only ones that have been used. It seems to me that selection might be broadened if you really took a look at the whole supply question.

HALPERT: Do any of the manufacturers want to comment on 304 and 304L or other materials that they might be using as to why they chose those?

CARR: Probably the reason we are using 305 is improved drawing ability. These are drawn containers. And with respect to drawn containers, it is not possible to hold the tolerances in 6.5. There are two different types of tolerances that have to be allowed and one is the basic tolerance on the tool and then in removal of the part from the tool they sometimes I guess use air pressure or other techniques which may introduce another slight deformation of the can. So these things have to be taken into account and I think we are probably more in the order of a total tolerance of around thirty-thousandths.

HALPERT: Anyone else on that subject?

HENNIGAN: One company here has said -- was it chromium, they would rather not use chromium because of stainless steel? Does chromium really have a problem with nicad cells or not? Shall we worry about it?

FLEISCHER: Jerry said that we shouldn't dig up any folklore.

(Laughter.)

FLEISCHER: But this is one case where there is some -- at Edison they insisted that chromium contamination of the cadmium negative active material will lead to loss of performance, especially in capacity.

Now, this is the only thing I know. I couldn't find any evidence that it had been experimentally tested or what the experiments were on which they drew this conclusion. That is the only evidence that I know of.

GROSS: I don't think that titanium cases are a completely dead issue and I would think it would be worthwhile to not exclude them at this time.

STEMMLE: What about a nickel case? If stainless steel has chromium in it, what about considering using nickel? Is it a matter of not sufficient strength or not equal strength to stainless steel or nonavailability due to the strike or what?

HALPERT: That is suggested in the spec.

YEKKES: Maybe some of the prime satellite manufacturers could make some comment about the desirability of drawn cases for heat transfer reasons in battery building versus the all-welded cases. Is there a strong desire to have drawn cases? Dr. Scott?

SCOTT: Jerry, would you rule on the -- would you rule on whether that is a point of order or not right now?

(Laughter.)

HALPERT: No, I can't.

(Laughter.)

HALPERT: Let's go on to the next question.

(Laughter.)

HALPERT: No, I don't think it has really been determined, at least to my -- I don't know whether I can answer it scientifically. I think it is just another place where we have a problem with weld there and a place for a leak. And as it is drawn it leaves you a little -- yes, okay, so you don't have that chance for a leak under those conditions

YEKKES: They are changing materials because you want drawn cases.

HALPERT: No. He says he is using 305 instead of 304 because it draws better, he thinks. And we are discussing the case materials which you are ruling on here. And I am curious as to how important it is to have drawn cases and are there some valid demands that are apparently moving some of the battery cells to be in drawn cases instead of double-ended

jon18

welded cases? Is it just a welding, inches of welding problem?

SHERFEY: The welded versus the drawn can used to be a matter of weight. There is a significant weight saving in the case of the drawn can. As far as I know this is no longer critical in the present spacecraft. But that was the original reason for going to the drawn can.

I think perhaps the reliability in terms of leakage in the drawn can would be higher than that of the welded can.

THIERFELDER: I just want to add one thing. When we went to the drawn can it was to remove the burr from the bottom of the cell because this was a problem in packaging the cells. So when there was a weld around the bottom that gave an additional burr to worry about.

HALPERT: Any other comments?

GASTON: My concern about the drawn cases if if you have a tall narrow case it is the inside taper and the effect of pressure so with drawing cases you have to look at the dimensions and see how much of a taper or how little of a taper because you like to have very little taper or none, but that is not practical in drawn cases, so you have to consider that in each specific design.

CARR: In line with Steve Gaston's comment, I think that the specification should include both drawn containers and fabricated containers because there are shapes

jon19

you cannot draw. Period.

Now, one other thing I would like to say is that in reading through the section on the ceramic seal I did not see where the cover material was called out. I may have just missed it. But, again, we would like to broaden that to the 300 series because we use -- instead of 304 we use 303 because it is a better punch part material.

HALPERT: Any other comments with regard to 6.1?

(No response.)

HALPERT: 6.2. I have a comment. To conform to trade jargon batch number should be replaced by heat.

Okay. Any other comment as far as 6.2 is concerned? Certified analysis. Is everybody happy with that?

(No response.)

HALPERT: Okay. 6.3. Again here I have a comment that batch number should be replaced by heat to conform to the trade jargon.

Any other comment with regard to that?

(No response.)

HALPERT: 6.4. Comment. Add if required after weld rod since not all welding processes require weld rod.

Any comment with regard to that and the MIL standard there, MIL spec?

(No response.)

HALPERT: Okay. On the tolerance on the can thickness and depth and wall, two comments. The mil tolerance for material and the range of .025 inches to .030 inches is specified at plus or minus .003 inches to 2 plus or minus .004 inches. Thus in specifying these tolerances a rework operation would be required.

Another comment. Wall thickness of plus or minus 1 mil can only be applied to sheet stock and would be very difficult to obtain on a drawn container.

Any other comments with regard to the wall thickness of the can itself and the prismaticity of the can if we are talking about a prismatic can?

(No response.)

HALPERT: I don't know whether it is realized here that we do get cans that have a great degree of inward bulge to them, and it does create stress on the plates and in the separator in the internal parts of the cell and I think it does have a definite effect on, or could have a definite effect on heat effects in the cell and therefore life. I wonder if anybody has ever thought about that or done any work along those lines to try to achieve a prismatic can, a truly prismatic -- or at least spec that part of the can.

(No response.)

HALPERT: Okay. We will go on to 6.6. Each can -- I am sorry, on 6.6 I have a comment. Since some defects are always present visual standards must be set. Also specifications should not allow brinding of weldments and other operations such as satin finishing and vapor blasting which are performed for cosmetic reasons.

Another comment -- no, I am sorry.

Any comments with regard to defect-free cans?

CARR: There is this thing about vapor blasting. In order to do an effective helium mass spectrometer test we find that we have to liquid hone the completed cell. So we do our leak check after a liquid hone. The liquid hone is also done for adhesion whenever we are using an encapsulation procedure to install battery cells.

HALPERT: Any other comments on this aspect on the outside of the can? The looks.

GASTON: I have one more comment. In my specification I see a passivation of all the welded areas to MIL-F-14072 finish F-300. I cannot explain at the moment why we have a passivation. Maybe it is something to be considered.

In addition, the weld penetration, some criteria should be set as to the penetration of the weld on the welded area.

HALPERT: Anything else on the can or the container?

SCOTT: Yes. Unless it is somewhere else where I haven't been able to find, I think something should be in here on cleaning of the internal surface of the container before insertion of the plate stack. And I think that process should

jon22

be specified or described in the information available.

HALPERT: Any other comments with regard to this?

(No response.)

HALPERT: Okay. Again -- we have now finished 6 and we would like to wait a little while before we get into the ceramic to metal seal, so in lieu of this we would welcome any comments again on the general nature, philosophical nature. I understand there were a couple of people who did want to say something earlier today that did not get a chance to do so. Now is a good chance for you to speak up.

STEINHAUER: Back on this cost question. This morning it seemed that the cell manufacturers were quite concerned with cost. The aerospace manufacturer is, too. But recognize that this nickel cadmium battery is normally the low reliability item of the spacecraft. It is also a relatively low cost item in comparison with the solar panel. And this is a life-limiting thing for the spacecraft. I think we can afford to put a few more dollars into the reliability of a long-life battery than we are currently doing and I don't think that the comments or the specification that we are working on should be limited, at least at this point, by an extreme concern on cost.

HALPERT: Any other comments?

RAMPEL: I want to refer to Specification 2.4 on individual plate determinations. It seems that the determinations are related to capacity measurements and nothing else.

If the reason for that is to get an idea of capacity, frequency or negative-positive ratio I would like to say that the negative-positive ratio varies with the current density and the temperature and the number of cycles.

And Item No. 2 is that those tests for capacity give no information whatsoever as to the oxygen recombination rate of the negative.

HALPERT: Comment along these lines? Questions?

(No response.)

HALPERT: With regard to oxygen recombination, I might make this one statement. It looks like we are going in the direction of having that as not as serious a problem as we used to have since we are now depending on various types of charge control devices, third electrodes, coolometers, strain gauges, and it seems that oxygen recombination may not be as great a problem as we have been led to believe early in the game, that we heard about early in the game.

KUHN: Perhaps the point he was trying to make may be that regardless of the importance of oxygen recombination you might use it as an easy criterion, as a test criterion as to the behavior of the product, the quality of the product.

FORD: I wholeheartedly agree with that comment. That is one area in this spec that has been totally omitted and I think there is a very big need to use this as a screening criteria in the production of the cell. And this becomes extremely important in third electrode type charge control, is the ability of the negatives to handle the oxygen and recombine it in an effective manner. And I think there is a place in the processes that I understand at this point that this could be used, and as a screening device.

What I am saying, it is going to appear in the spec later on.

(Laughter.)

HALPERT: Anybody else comment in general?

GROSS: I have a minor comment. Item 2.3.1 where plates are to be put in containers, I wanted to point out that some plastics will pass carbon dioxide vapor fairly readily, so the container should specifically exclude the passage of CO_2.

KING: I would just like to say that we are still stressing oxygen recombination, even though we are using charge control devices in the event that such a device should fail. We still would be assured of long runouts by our battery, and we will stick to this recombination for a long while to come I believe.

DUNLOP: I think Dr. Pampel from GE was bringing up a point that what you have in a cell when you first test it may vary a great deal from what you might have in a cell after it has run under certain conditions and for a certain number of cycles, et cetera, et cetera.

I think, though, that the intent here is to find out what you have in the cell to begin with and then you can do what Dr. McCallum was trying to do, and that is figure out what kind of failure analysis you go into after the cell has gone through some kind of time history effect. But if you don't know what you had to begin with then you haven't got a very good baseline to compare what the effects of different cycle or temperature or performance is.

The other point I would like to make is I am sure everybody here realizes the importance of the oxygen recombination effect and we don't want to write that one off, with third electrode charge control.

One more point. I am going to start talking here since I haven't made much noise yet today. I did -- sitting across the table from Steinhauer when they went through the design review on Intelsat 4, it was very interesting to note that for the power system the reliability of the power system was determined almost on reliability of the batteries. This is the reliability analysis for the entire power system including the charge control, the regulation for the entire spacecraft load, the solar arrays, everything that you could consider in the power system for the satellite, and that reliability number for a seven-year lifetime was identical almost to the reliability for the batteries because the batteries are so much worse than anything else you put in there.

FORD: Jerry, I would like to make one other comment. One thing has become quite obvious in the past couple of years in regard to this negative-positive ratio, the over-charge capability of cells, et cetera.

The approach in the past has been to design a cell over a broad temperature range, take one item, one design and use it for all applications. It is becoming more and more clear with passing time that this is not necessarily the best way to go.

What I am trying to say is simply this, that a satellite, like a communications satellite, that is going to present an environment to a spacecraft battery of 60 to 90 degrees F. would not necessarily use the same cell design as a satellite that you can give a battery a zero to say 32 to 50 degree F.

I think we have this information at our fingertips and we are just beginning to realize that it becomes a very useful parameter in long-life batteries.

SULKES: Going back to something specific, 2.4.2.8, it calls out a paragraph and I can't seem to find it. What it means, to cut them to cell size and coin them to proper size.

HALPERT: 2.1.1.1.9 instead of 2.1.1.6.

FLEISCHER: I would like to go back to Rampel's oxygen recombination determination. We do actually have in Section 8.8 an over-charge test in which the cell on-charge voltage is specified and in a way this is an oxygen recombination test, but I wasn't quite sure whether you propose that we measure the oxygen recombination of the individual negative plates or of the cell as assembled. So if you have a method I think everybody would like to hear it.

RAMPEL: What I was referring to is that it is just as important to consider that as it is to just consider capacity per se in those individual plate measurements. But in the individual plate measurements which I imagine the most important aspect is to decide on the negative-positive ratio I think that we have to be aware of the fact that the negative-positive ratio changes depending upon the rate of charge discharge and the temperature, because of the charging acceptance of the positive at the cold end compared to the hot end and what happens to the negative plate at the hot end. It faces. And the number of cycles that is conducted. I think those things have to be spelled out because otherwise the negative-positive ratio as determined at room temperature, you may still get into trouble at other temperatures.

Specifically answering your question, though, on the oxygen recombination, yes, I do think that each negative plate lot should be -- the recombination rate should be decided early in the game.

HALPERT: In answer to that one point, we not only measure the capacity of the electrodes, we also measure the oxygen free charge capacity and the high energy free charge capacity and negative and hopefully some of these physical measurements that we make on both the positive and the negative will relate back to some oxygen recombination rate that we hope under the controlled conditions would be fairly uniform. We are not sure that it will be, but it might be a help in that regard, rather than trying to measure them on an individual plate which would mean very little inside the cell as you have just said.

BELOVE: Continuing on what Guy Rampel said, it is our feeling that the negative-to-positive ratio is important and should not be considered in the realm of 1.2 to 1.4 to 1, but higher.

We have gotten into working much higher ratios than that for the very simple reason that you do not always know the environment that the battery is going to be used in, nor do you know the exact current density on charge or discharge. These are varying factors in many of the uses in satellites and for that very reason that ratio must be greater than what is prescribed, the usual 1.2 to 1.4 to 1.

GROSS: In referring to negative-positive ratios, I think we have to distinguish between the theoretical ratios and the ratios of what you get in the flooded test.

Secondly, with regard to the measurements on oxygen free capacity and hydrogen free capacity it is known, of course, that these are functions of rates and temperatures and the state of charge, a variety of things, and we have to consider the complex functions that these relate to in asking for this requirement and pick a condition at which we want the test run.

KING: Continuing on the subject of the overcharge and oxygen recombination, I might mention that we test all our cells from plus 40 down to minus 5 to minus 12, and the test at minus 5 and minus 12 is 120 hours of overcharge at the C over 10 rate without the pressures rising above 75 psi as measured. And we have been running as low as 30 psi after the 120 hours.

FORD: Is that degrees F?

VOICE: What temperature?

KING: Degrees C.

CORBETT: On Mr. Green's comment I would like to ask him what kind of voltage you expect to see at those low temperatures. Do the numbers stick in your mind there?

KING: Yes. If the voltage exceeds 1.5 at minus 5 degrees centigrade the cell is considered rejected.

STEINHAUER: Dr. King, do you run into any problem with hydrogen at minus 5 C in a C over 10 charge? Does this pressure recombine?

KING: As far as we can detect, and we have made measurements on this, there is no hydrogen being evolved from our cells. We have had hydrogen evolved at other temperatures under other conditions and have identified it as such, but at minus 5 on the cells I am talking about, no.

CORBETT: I have one more question to Dr. King.

Is this the end of charge voltage or is this the peak voltage reached at any time during the 120 hours?

KING: The 1.5 volts is the end of charge voltage at the 120 hour mark. Occasionally we have seen a slight rise and we do allow up to I believe it is 1.57 for a period up to the first 7 hours and after that the cells have to settle down to the 1.5 or lower.

Usually the cells are running about 1.53, so that we are well below our cutoff voltage and at the higher temperatures we are looking at 1.45 volts.

HALPERT: Anyone else want to comment or make some general comments?

We are kind of stalling here, as you can gather. Coffee is about five minutes to go and we would rather not start something and then have to get up and leave it.

With relation to some of the comments that someone has made on the tests, I think that once we are able to reproduce some of our basic material in some of our plates, when we do start looking at the plate materials in terms of the optimum type of cycle, whether it be a synchronous orbit or 30-60 type of orbit, we can design better and make better designs of our plates, but at the moment since we have plates that still do vary quite a bit and one group is so much different than the other we still cannot base any particular measurement or design change. That is it is difficult to make these changes based on the end design of the cell. And hopefully by the time we get finished with this we will be able to implement some of these changes and some of these controls so we will get uniform materials that can be reproduced from time to time and then know better where we sit with regard to how the cell is actually working under a given set of conditions.

KING: Just one correction. I said -- I believe I said 1.5 volts. It is 1.55 at minus 5 degrees.

HALPERT: I think everybody breaths a little bit easier.

GROSS: I want to help you use up some of your extra time. I will make this comment that I didn't see in the spec any requirement as to whether the tabs were to be attached after impregnation or before. I would prefer to have it done before. There are some problems that you can get into I think you can understand if you do it afterwards.

HALPERT: I think there was some discussion --

FORD: I believe if I recollect that somewhere in here it is stated that the tabs shall be an integral part of the grid structure, of the metal structure. I know that does not apply equally, but that has been considered.

CARR: As most of you are aware, our tabs are not an integral part of the plate structure and we do put them on after we cut the plate. In fact, we punch the plate. The process here, again -- this gets into an area I think where we don't care to argue our process against someone else. Again, it has its advantages and its disadvantages. But there if, like Dr. Fleischer says, you do it right, it is good.

(Laughter.)

HALPERT: You attach the tabs to the plate and not the plaque; is that right?

(Laughter.)

STEINHAUER: Since we have a few minutes I didn't want to leave Jim Dunlop's comments completely unanswered on reliability, but I think there is one thing we have to look at and perhaps Dr. McCallum can comment. Our reliability predictions are only as good as the data that we can put into them and we have that cream type of data, we have telemetry type of data and we are talking about five and ten-year missio now. We haven't any real time testing on these nicad batterie out to that point and therefore our reliability predictions may be somewhat more pessimistic than they might be if we had more data.

DUNLOP: They may be optimistic, too, you know.

(Laughter.)

STEINHAUER: That's right.

HALPERT: I did hear one comment this afternoon one of the manufacturers made and that is that they really don't get a feedback of some of the aerospace data on batteries and they really don't even know how their own batteries are doing in space, and I think this may be a lack or break in the communications somewhere. I think they should be fed back. We want as much information as we can get from them. We certainly want to feed them back information on how their materials are doing

STEINHAUER: They hear about the failures.

HALPERT: And the failures did you say?

STEINHAUER: I said they hear about the failures.

HALPERT: Yes, they do.

HENNIGAN: I would like to comment on that. Normally we don't get too much information back on batteries until they get in trouble, and this is when they get on failure design review committees.

One thing I would like to mention too about the cost -- I have been in several that failed like in integration or during a procurement -- not procurement, during integration and maybe even at the launch pad, and these are very expensive items. We kind of figure the OAO was costing at least a million dollars to turn around. Is that a ballpark figure? To get a new battery. Now, this wasn't for the battery, this is because you are holding up the Cape, you are holding up thousands of people in this country waiting for something. They don't have anything to do in the meantime unless the spacecraft is on schedule. So there is where your expense comes if you have battery trouble.

GASTON: I have a comment. I would like to make one correction on what Tom Hennigan said. The OAO spacecraft was not held up because the batteries were late. There were other items which were late. The OAO was launched on schedule. It was not the battery that held it up.

HENNIGAN: It cost a little more.

HALPERT: Hopefully the coffee is ready out there. We will break and then come back and talk about ceramic metal seals.

(Recess.)

HALPERT: I would like to continue on this afternoon in the ceramic to metal seal area, and at this point I would like to turn the meeting over to Bob Steinhauer of Hughes who has done a great deal of work in this area.

Bob Steinhauer.

STEINHAUER: Thanks, Jerry.

The spec has been written to an active metal process and we are quite aware that there are people using the mullimanganese(?) process and it is not an intent to exclude that.

We have some comments that have been sent to the Committee on 4.1.1 that there should be a list of approved ceramic bodies and suppliers. And to add the specific gravity in 4.1.2.

Are there any comments on that?

CARR: Exactly how is this going to be determined?

STEINHAUER: Well, this spec as written of course calls out I believe a 99.4 percent body. There are several that are being used and we may want to list specific suppliers and the approved body that has been done previously in vacuum tube industry.

CARR: Would you do this rather than include the requirements for the ceramic in a specification? I don't quite understand. In other words, in writing the specification is it going to have the requirements for the ceramic in it or is it just going to have the vendor's name and his part number? This seems to me to defeat what we are trying to do here.

STEINHAUER: If it is to be all-inclusive we would -- this could expand the spec quite a bit. I think there are specs already on ceramic bodies that could be referenced.

CARR: I understand. We are working with a vendor and I guess we work with 94 percent, 97 and 99 percent in our programs right now. We would be glad to furnish this information for the spec review or additions to the spec.

STEINHAUER: I appreciate that.

UBANKS: I have a question about the 99.4. As he points out, 96 percent and 94 percent have been used to make good seals. Is the purpose for this 99.4 because of the glass content or the lower alumina(?) content so that you do have --

STEINHAUER: That is the specific concern, yes.

UBANKS: So you don't want to use anything but 99.4?

STEINHAUER: I think this has yet to be resolved because we do have proven seals used on these nicads with a 96 percent body, and I think we would definitely want to entertain further comment -- further information to the committee on that.

UBANKS: Well, I am assuming that the 99.4 percent is because of the lower glass content, therefore you don't get the attack. Maybe that is the reason that you put that in there.

STEINHAUER: Yes.

VOYENTZIE: I think the main point here is just what the remaining impurities are. I am not certain that the .6 percent versus the few percent and the 96 percent make a difference. It depends exactly what these impurities are and how they are attacked. The 96 percent works excellently.

STEINHAUER: Usually the major percentage is silica on the lower bodies.

BELOVE: Another comment relative to what we have spoken about before. Again, we are specifying a material. We are not putting down limits, or not asking for data, but we are now specifying ceramic.

Now, I have no grudge against ceramic. We have used ceramic and we are using ceramic, but I happen to know that there are plastic seals that are good, have proven excellent through the years. Nevertheless, this specification precluddes the use of any seal other than that using ceramic. I don't agree with this concept of the specification.

STEINHAUER: It is not the intent to exclude the other seals. This specification, as you realize, in the black area and in some of the areas that we discussed this morning, was exclusive there. It is not intended to be there nor here either. I think we would want information submitted that would give us information on the type of seal you are referring to.

FORD: You are saying -- the gentleman from Sanatoni(?) -- are you saying that the plastic seal is a proven space seal? Has it been used in space applications? Are you saying it has been used in battery manufacturing?

BELOVF: It has been made or used on battieres that were intended for space. Some have flown many years ago, but we still have batteires around in the laboratory that are showing no leakage after many, many years during which ordinary ceramic seals have shown leakage. And what I am saying is while we do not have space experience equivalent to ceramic, the seal appears to us, on a technical basis, appears to be worth while including in the specification, providing that the seal can meet some given requirement and if you specify that I can understand it. But what you are doing is specifying a material.

STEINHAUER: Any further comment?

GROSS: This specification is going to -- I think it is going to require some design changes, or at least manufacturing changes. With that in mind I would like to see a stress analysis of any new ceramic seal that is developed. I think that this is one of the reasons that we have leaks is because the engineering is not analyzed properly to begin with.

BREDBENNER: The seal design that is currently being used on battery seals has been used for over ten years under much more severe conditions than the battery seal is exposed to.

STEINHAUER: The one thing present of course is the electrolyte that you do not see in a vacuum tube application.

jon39

On 4.1.2 we have a further comment. Is there a particular dye check procedure which is recommended?

I think almost any company you go into you will find a different one.

BREDBENNER: This is normally a requirement put on the ceramic manufacturer. The one I am assuming here is one that we would perform also to assure that he just hasn't passed it up. It is just a simple emersion in a fushine(?) dye. Then possibly taking these samples and breaking them for difusion of dye into the ceramic.

STEINHAUER: Before we --

BREDBENNER: One more comment on that. The dye check used by ceramic industries is under 4000 psi pressure normally, which is quite a severe test.

STEINHAUER: We have, in addition to the comments that were submitted to the committee earlier -- Mel Bredbenner has submitted almost a complete specification to us for consideration for these metal ceramics which is quite detailed and a little too lengthy to go into here. It parallels, however, what is in the spec but is a little bit more specific in certain areas.

Now, there are some comments that have been made on 4.1.2 making dye check after mechanical inspection but prior to 4.1.4, prior to the chemical cleaning. Is this an appropriate point to make the dye check? Any comments?

UBANKS: I think probably the reason for that would be that if it is going to be done by the ceramic manufacturer, this is one thing, because the part might get chipped or the dimensions may be wrong after the person who is making the seal gets them. But if the dye check is going to be made in-house, if a part does not meet the dimensional requirements it would be better to weed these out before you make the dye check.

STEINHAUER: I have no comments for 4.1.3. This is on mechanical inspection in connection with chips, cracks.

BREDBENNER: I have one comment. I think the 100 percent inspection is fine for everything there except for dimensions. I would suggest LAQ Level 2, MIL-STD-105D.

STEINHAUER: We have a comment on 4.1.4, air dry at 120 centigrade after water wash as a recommended practice.

UBANKS: Could you -- I believe this is your comment -- could you give us the rationale behind that?

VOICE(?): Well, the reason I made that comment is because this is sort of standard procedure, is it not, that after chemical cleaning it should be air dried thoroughly. This may obviate -- I think it obviates the necessity of 4.1.5 where you do the air firing after the chemical cleaning, but I think that air drying at 120 after the wash is necessary to get the parts completely dry before doing the air firing.

STEINHAUER: But you do still recommend the air firing?

VOICE: Yes.

BREDBENNER: After the dye check one step is necessary to take the dye out and this normally involves a nitric acid dip and in giving the nitric acid dip you also remove mental marks that might be on there. If you don't remove them at that time when you air fire you would burn them right in so it is necessary to remove the dye and any metal marks. And then this air firing should exceed 450 centigrade in order to burn off organics or else they will just turn to carbon on there. So the 1000 degree centigrade is fine. It is used on most high reliability jobs that I know of.

STEINHAUER: There is a comment that there should be slow cooling after this firing and then to store in polyethylene bags, but no longer than three days before metalizing. Clean ceramics must not come into contact with any metal parts during handling, tweezers, et cetera, are applicable. It should be bone-tipped or coated with plastic. Since all traces of metal marks, slivers, et cetera, must be removed to assure good metalizing. Some manufacturers boil metal parts in nitric acid for periods up to thirty minutes followed by rinsing and boiling in deionized water for thirty minutes prior to step 4.1.4. Care should be taken to protect ceramic parts from contact with pilot flames and gas flame curtains while entering or leaving furnace. Parts should be fired in ceramic trays or plates, not in metal. Any comment on that?

BREDBENNER: Obviously this describes a molymanganese process. The use of plastic-tipped tweezers is simply out because it can leave organics which don't burn off in a vacuum.

UBANKS: Well, maybe the term plastic should be removed. I would like to keep the burn tip in. What I am trying to do, in other words, is to keep the metal marks from getting on the ceramic part.

STEINHAUER: Another comment on 4.1.5. We do not see the technical justification for air firing. The alumina had been previously fired to form the ceramic cylinder and it is once again fired during the bracing operation.

Comment on that?

BREDBENNER: It is probably not as important in molymanganese metalizing, but much more important where you are firing in a vacuum. You have got to make sure that you have got everything off there.

STEINHAUER: Any other comments?

BREDBENNER: To clarify that, it is the water vapor in your molymanganese type firing that combined with carbon produce carbon dioxide and hydrogen which removes the organics but you don't get this in vacuum obviously.

RUBIN: This is a question I ought to direct toward

Ceramaseal Manufacturers. Does this air firing cause migration of any glassy phases within the body? How is the glaze affected during this air firing? And does it penetrate the body under these firing conditions?

BREDBENNER: The softening phase in these ceramics that are specified, the glassy phase, that is, is up around 1400 centigrade, so obviously you are not going to get any glass migration.

What was the other question? Oh, the affecting of the glaze. In my specification that I submitted was that the glaze -- one of the requirements is that the glaze must be able to take 100 degrees centigrade in a vacuum at 10 to the minus 4 without chemical or -- let me find it here -- must exhibit thermal and chemical stability in vacuum 10 to the minus 4 at temperature of 1000 C.

STEINHAUER: I would like to comment on the need for air firing even in the molymanganese process. We found in vacuum tube industry to be extremely critical. It is highly desirable.

Comment on 4.2. We do not have a ball mill process. Particle size is certified by the vendor from whom we purchase the active metal material. The certification should satisfy the intent of the specification.

BREDBENNER: I would like to make some changes in 4.2.1, .2 and .3 there. I agree with the comment that you made. What I would do is specify a powder of, in my own case, 99 percent minimum purity titanium, ballmill another powder if it will not stay in suspension without constant stirring after mixing with organic suspension vehicle.

Now, this was written to constantly stir it and I think we ought to have a mix that doesn't need that.

Another point here is that we are using a one-component powder. We needn't worry about various -- for instance, if you had a two-component powder of 80-20 and you didn't keep the right distribution there you would obviously foul up your metalizing. One-component powder, you can only put it on one component. So the worry here is unwarranted.

I think the ball milling should specify the things that are stated here and I specify a ________________ also.

UBANKS: Shouldn't we also specify a particle size like less than 7 microns or something like that rather than say particle size and size distribution should be --

BREDBENNER: Up to recently we bought a 300 mesh powder and it always was fine without any ball milling. Recently this company stopped making the powder and we have had to resort to ball milling in most cases. We are still buying the same mesh powder, but most of the time it needs ball milling.

Certainly there is a certain size here that you need, or a size distribution that you need, but after the ball milling and a specified time and doing it properly and then putting the powder in a mix, I think that is a good enough test to determine whether it is going to stay there.

STEINHAUER: Further comment on that. In moly-manganese the particle size was important, but even more important seemed to be the particle size distribution. It could get drastically different results unless you reproduce that distribution.

I have a comment on 4.2. Active metal is a term usually applied to titanium zirconium hydride which is used in ceramic metal seal processes but is different from the sintered metal powder process, commonly called molymanganese but which includes molymanganese and a number of other metals. Use of the term active metal may be confusing unless you mean to say that only active metal processes will be used in the seal manufacturing which I don't think you do.

No, it is not the intent to exclude this. There is some concern on the attack by koh of a molymanganese metal-izer. If you can protect this -- this would be of concern if there is data to show the seal to be adequate.

CARR: We are currently working with a different vendor on a new metalizer so I would recommend that in writing the specification that you put down what you want in the matter of controls rather than discussing the, you know, the two processes we are talking about. In other words, what we are trying to say is well, we want to use bone-tip tweezers so we don't put any metal on it. I think we ought to say we don't want any metal on it.

STEINHAUER: Okay. We have no comments on 4.2.1. On 4.2.2 I have a comment. The Mill winer and ball composition should be high alumina composition to avoid contamination of the metalizing mixture.

Any comments on that, or other comments?

(No response.)

STEINHAUER: Okay. No comments on 4.2.3.

4.2.4., standards should be set for green metalizing thickness. I think that is fairly standard as a control.

Okay. I don't have comments until 4.4.3. Anything between 4.2.4 and 4.4.3?

BILLERBECK: 4.3.1 here, I believe, Bob. Test should be on actual design configuration, referring to tensile test.

STEINHAUER: We have some comments that we have been asked not to include here for the moment.

BILLERBECK: Okay.

STEINHAUER: Paragraph 4.4.3. We question the validity of a braze flag test on an alloy whose contents are certified.

Any comments on that?

(No response.)

STEINHAUER: Well, then, I would like to comment.

In dealing with a great variety of braze materials, and there are only a limited number of sources for these precious metal alloys in this country, where we were performing hundreds of spectrographic analyses a week in a vacuum tube operation, we found that it was not an infrequent occurrence that the alloy you got was not the alloy you ordered.

A certified analysis doesn't mean a whole lot here and the braze flag test and a lot spec analysis seem to be minimum to control that.

On 4 -- I have a comment on 4.5.2.2. Is there anything that anyone would like to say between 4.4.3 and 4.5.2.2?

(No response.)

STEINHAUER: 4.5.2.2. It says this test is redundant as pinch tube-cover welds are inspected as part of the general cover inspection.

HALPERT: I think it was mentioned by someone before in this area 4.5 is where we should possibly spell out the alloy used in cover assembly, whether it be 304, 303 or what.

STEINHAUER: Yes. I think this is important, particularly on this cover and particularly where you are making a braze to that cover.

Mel, would you have any comment on 304L versus 304 or other stainless materials where you are going to be contacting a braze material?

BREDBENNER: I think 304L for higher reliability. I think 304L having a low carbon and never having to worry about carbide precipitation is important, it is possible in some of these welds that there could be a point for corrosion here.

303 was mentioned earlier. It has sulfur in it. It is no good for welding. There is a 303MA material recently developed that is supposed to be weldable. Nickel is probably the best material as far as not getting into trouble.

STEINHAUER: Yes. I would agree with that particularly where braze alloy is in contact with the material.

RICHARDSON: On 4.5.2.1, talking about 100 percent inspection there for the cracks, porosity and this type of thing; you are talking about the weld on the pinch tube in this area? On this 4.5.2.1, are you talking about the weld to cover the can or cover the case?

STEINHAUER: This was on the cover assembly, so I am quite sure we are referring to the pinch tube.

RICHARDSON: Okay. There you get into a problem when you are talking about porosity. You get a lot of porosity that is below in the welded area and you are talking about inspection, you are not going to see it, not unless you x-ray it. And there is also the possibility of internal cracks, and here again -- here you say inspection. What do you mean, are you talking of visual inspection or radiographic or what? You say 100 percent. It is not clearly defined there.

STEINHAUER: The items that are called out would indicate a visual inspection, and I would agree it is probably not adequate.

RICHARDSON: We ought to say maybe a visual -- if you do say visual you probably won't see any cracks with a visual or anything like that.

STEINHAUER: If it is a weld this is true. Visual is very useful if it is a brazed pinch tube to the cover, as far as the filleting and so forth.

RICHARDSON: You know, it is a pretty small area actually and cracks and welds, we have seen cracks at Marshall under x-ray and they are small minute cracks that you can't see with a visual inspection whatsoever, even after looking at them under magnification occasionally. We actually view x-rays under magnification. But here again, we are working with high pressure type of welds and a structure that you are requiring to take high pressures and vibration and various harsh environments, whereas this, there could be some high pressures involved, but --

STEINHAUER: Recognize that in a welded assembly this would be true. In a brazed assembly x-ray may not be an applicable technique. It is very difficult in a ductile alloy.

RICHARDSON: Then you get to the point if you x-ray what is acceptable and what is not acceptable. And you can get all kinds -- you get into problems there also.

STEINHAUER: Great.

GROSS: I agree with the speaker. We have tested by x-ray a number of seals and in all cases been able to detect some defects.

I would like to add a general -- I would like to see a statement added in the specification which gives preference to seal designs that can be inspected by x-rays. Most of the seals now manufactured can be inspected by x-rays, but it is extremely tedious and a difficult operation.

STEINHAUER: On 4.5.2.3, cover assembly lot is undefined. This is one sample per lot. We haven't specified a sample size and this, of course, is going to depend on an individual manufacturer's process, the number that actually goes through in a batch assembly.

Any comments on that?

GASTON: I have a comment on 4.5.2.1. I believe that you also inspect for weld splatter which occasionally occurs and probably could eventually fall into the cell.

STEINHAUER: If it is on the underside.

GASTON: If it is on the inside.

STEINHAUER: Yes.

SCOTT: With regard to 4.5.2.3, I think this is one of a number of cases where possibly the final wording maybe should be referred to the MIL Standard 105D or other applicable sampling plans and not just numbers picked arbitrarily out of a hat. I think maybe we need to go through this thing in a number of cases and actually look at what is available and what is being accepted in terms of statistically valid sampling plans and work those into the spec.

STEINHAUER: Yes, I agree. The question is, though, that each manufacturer puts through a certain lot size of parts through their process and the variables that you get within that batch may not be the same as the next batch and I think the original intent of this was one sample per manufacturing batch to know that the furnace or the vacuum braze was in control for that lot.

It would be nice if this was a continuous process and it would definitely lend itself to statistical sampling.

BREDBENNER: One thing that is omitted in this group is spot welding and the quality thereof.

STEINHAUER: Of the negative terminals or where in particular?

BREDBENNER: Well, there is either a comb or a lug there on one side and a lug on the outside of the can.

STEINHAUER: True.

RICHARDSON: Also your third electrode there also spot welding it is a possibility. You have a tab attached to the third electrode which attaches to the cover.

STEINHAUER: Yes.

FORD: I might point out it is probably already obvious to many of you that the spec deals with a standard aerospace type cell. There is no attention addressed to the third electrode cell in the spec. However, it will be a natural fallout that after this spec is finalized the third electrode requirements will be included as part of the final specification.

GROSS: With Ford's comment in mind it would seem reasonable to make sure that the format and the paragraph number assignments have adequate room for new things that are going to be added at a later time so that they will fit in in a logical manner.

STEINHAUER: Okay. On 4.5.3.2 it is recommended the use of dual thermocouple one monitor at the bottom at the end of the load zone and one control at the center of the load zone. Chart recorded.

This is a matter of process control on the furnace or on the equipment.

The next comment we have is on 4.5.2. Are there any comments between 3.2 and 4.2?

(No response.)

On 4.2. Why does the customer need this type of information, especially since the end product undergoes such rigid testing?

This is in reference to the recording of the braze time and temperature cycle.

UBANKS: Well, it may not be necessary for the customer to really know these numbers, but as a matter of process control I think they should be recorded, and of course if the customer would like to look at these data books and so forth, if something goes wrong I see no reason why he shouldn't. But I do think that this information should be recorded as a matter of process control, braze time and temperature.

STEINHAUER: I definitely agree with that. It has been extremely useful to be able to go back in one case to complete lot traceability and find out each variable within the metal ceramic process of a lot that failed to see if there was any correlation. It turned out not to be, but it was extremely useful to have that information.

4.5.4.6.

RICHARDSON: Back on this 4.5.4.3, you say visual inspection using magnification where required. This could give you a problem because if you don't spell out magnification one inspector is going to use a 5X, you know, and the next guy down the line will use a 50X and he rejects the whole damn bunch because he sees something under there that you don't see under the 5X, so if you are going to say use magnification you ought to spell out 5X, 10X or else say visual period assuming now allowing any magnification.

STEINHAUER: Agreed. It is common to use 10X in the vacuum tube industry. I would make that as a suggestion.

RICHARDSON: It ought to be spelled out.

STEINAHEUR: Agreed.

Anything on 4.4, 4.5? Insulation resistance, leak check, 100 percent?

(No response.)

STEINHAUER: On 4.5.4.6, 5 percent random sample is considered excessive. This is on braze quality metallurgical sectioning.

Everybody agrees? Five percent is all right.

HALPERT: Five percent of what?

STEINHAUER: Of the number of parts.

HALPERT: I think that you have to spell out what the sample is and determine how many you are going to check from there, how much is a batch. That will tell you what the random sample should be, especially if you are going to use a MIL-STD-105 which will tell you how many you could then look at. So 5 percent could be a lot or it could be a little.

BELOVE: The procedures specified sample size based on a percentage of a lot is a poor way of selecting a sample.

STEINHAUER: I think what we have to do is define a manufacturing lot from a sampling or statistical standpoint. Yes, we should specify a MIL standard procedure, but each person making metal ceramics has a different manufacturing lot size, and is this sampling procedure through different manufacturing lots applicable?

BREDPENNER: It is impossible to apply MIL-STD-105D on destructive testing. If you have a lot size of 10 you will bust almost every one of them. You have got to somewhere when you are doing destructive testing use a percentate figure. When it gets into real small lots, obviously you don't get enough, but you should do at least one or two. So you can set a minimum number based on say you are doing 25 pieces you would wreck one or say we will break one out of every 25 or not to exceed 5 percent of the total lot.

STEINHAUER: Yes, Jerry?

HALPERT: Would you expand on your statement? Were you talking about only the ceilings now or about all samples? Would you expand on what you mean?

BELOVE: I was paraphrasing what you were saying before about the MIL spec is based upon the fact that in order to get a decision based on a number of rejects that describe the level at which you will accept and reject, that in turn works back to tell you what an average sample number should be. And specifying the percentage doesn't perform that task. In fact, it works against you.

STEINHAUER: Comment on 4.5.4.6, destructive peal test to see entire bond area and adequacy of bond.

I believe that was a Ceramaseal comment. I take it that is a recommendation? Destructive peal test to see entire bond area and adequacy of bond.

BREDBENNER: The reason for that was the fact a metallurgical section only sees -- you only see a small part of the seal. Ceramic to metal seal is commonly the best way to check them is to peal them. You get a feel for the strength as well as you see the entire bond area.

STEINAHFUR: And your concern was whether you pull ceramic or -- okay.

HALPERT: Is that a standard test?

BREDBENNER: Yes.

STEINHAUER: Are there any further comments in this section?

(No response.)

STEINHAUER: I believe Mel Bredbenner requested to comment in general on metal ceramics. Mel? No? Okay.

MAURER: I have a comment. I think we should consider another test on some sample of the lot which includes thermal cycling of the seal, perhaps in a dummy cell configuration with voltage applied. This has a tendency to accelerate leakage of potassium hydroxide along certain elements in the seal, say minus 48 degrees centigrade to plus 160 degrees -- sorry, Fahrenheit -- one hour each for 40 or 50 cycles.

STEINHAUER: As a shock test between the two temperatures?

MAURER: Not really a shock test, no. Just a thermal cycle that allows sufficient time to not induce great strains in the seal. I am not thinking of the thermal shock so much as just flexing it.

STEINHAUER: Yes.

MAURER: And this induces weak points to break and leakage to be induced.

RAMPEL: I think along those lines that should be a qualification item on the seal when first designed because if you are going to bring that sort of thing in you also have to take the ceramic material and boil it in KOH for a few months and measure the rate loss and do catotic and anodic(?) oxidations and so on and so forth and I just assume that this was done in the beginning when the seal was designed and qualified.

SCOTT: I tend to agree that the type of test indicated by the numbers for the thermal cycling and all don't appear to me to be suitable for in-process control testing.

They are more of a qualification nature.

BREDBNNER: It is common to call out a requirement that this assembly must take thermal cycle from such to such under certain conditions, yet not required as a production test. It can always give you something to fall back on if they don't pass.

Maybe I shouldn't have said that.

(Laughter.)

GROSS: The thermal cycling test is nevertheless very useful for determining if in a general sense how good the cell seal is and it would be useful in picking up any long term changes in a particular design. So an occasional cell seal tested in this way would give you an idea of how that particular seal has changed over the years.

STEINHAUER: I would like to comment here. I am strongly in agreement on thermal cycling, but recognize that the metal ceramic or any seal that goes through a furnace or vacuum braze operation gets a pretty severe thermal test after that braze solidifies. But still, thermal cycling, we use that intensively ourselves, both in military and space applications.

Yes?

MAURER: I was going to say that some ceramic seals will fail this test in one cycle. Some plastic seals will fail it in a few cycles. And a well designed plastic seal will last for 2000 or 3000 cycles. The longest ceramic seal that I have had experience with was about 40 cycles.

Now, if you have an automatic -- a programmable oven, cold chamber, these cycles can be carried out, 40 cycles in roughly a week's time with no trouble at all. So we are talking about a week's worth of work, not months of work.

STEINHAUER: Anything further?

RICHARDSON: Talking about minus 40, you said plus what, plus 160 or something like this?

MAURER: What temperatures you are operating your batteries at. Our batteries are hopefully operated in a fairly nominal range above -- around zero degrees C to maybe plus 30, so really we are not going to see a tremendous amount of thermal shock on these seals. So normally if you are testing to these lower range limits and higher range limits it is normally in qual area when you get to exceeding these -- if you were to run acceptance tests on seals you would want to maybe run them in a range that your batteries were going to see. If you are going to operate them from zero to plus 40 C, maybe that is the range you possibly might want.

MAURER: I agree we want to modify these numbers based on your use mode. In the Bell system we see temperature variations of this type. However, you want your test to exceed the limits of your application so you have some margin of error in the ceiling. You might not want to go to the extremes that I mentioned, though.

BREDBENNER: I think the real thing that causes these seals to fail is not temperature, but pressure that builds up inside. Just simple thermal cycling wouldn't do anything. We do it on everything minus 50 to plus 150 C. But I think it's the pressure buildup on the high temperature side that causes the seal to actually fail, and this involves getting a strength value on the design as such, on a push out of the seal, to see what it takes.

MAURER: Isn't there a flexing in the seal area that occurs during a thermal cycle, and would this not tend to cause fatigue in a bond that's not as good as it might be?

BREDBENNER: The seal as designed is under compression, and any heat you put to it begins to relieve that stress that's already on it, until you go above a certain point -- which is above 450 C., usually.

In the range we're working in, we're actually relieving the seal. In addition, in the flange area, there's a built-in flexing, relieving the pressure on the seal area.

STEINHAUER: I would like to comment on something that I forgot to say before on 4.3.1. The original intent -- I think this was a typographical error -- was to have the sample tensile strength must exceed 6,000 psi, which is not an unusual number for any of these processes, rather than 600.

Further, on this question of pressure that has been brought up, we have tested the ceramiseal seal by taking a nicad cell and pressurizing with nitrogen gas. The yield point, when the ceramic started lifting and the stress relief collar bending over was between three and four thousand psi. This is what the cell major walls restrained.

So the small pressures that we typically see in orbit -- 75 to 100 psi, or more typically down around 30 psi, are really not excessive for these seals.

MAURER: I'm thinking of fatigue cracking.

STEINHAUER: Cycling -- yes.

Okay, I think that covers the general ceramic section.

HALPERT: Thanks, Bob. I want to remind you -- if you haven't signed the attendance list, that's important, not for attendance but to receive copies of the minutes of this meeting. So anyone who has not signed the sheet with their name and address, please come down to the front after the meeting and do so, so you'll be sure to receive that.

At this point I think the next section we go to is number 7. We're going to skip over three until tomorrow morning. The next section is number 7, "Production Processing of Electrode Assemblies." And for this part of the meeting I'll turn it over to Floyd Ford.

FORD: Could I have your attention, please? Okay.

We will get started with Chapter 7, "Production Processing of Electrode Assemblies."

I have one general comment from a particular manufacturer that says:

"This chapter applies to a specific process and by its nature excludes all other processes."

I have no comment on paragraph 7.1.1. Is there any comment from the floor?

Paragraph 7.1.2 --

RYDER: Ryder, Gulton. I do have a comment on 7.1.1.

FORD: I beg your pardon, I found it. Comment:

"Is there a technical justification for the control of humidity in a formation facility?"

That is pertaining to paragraph 7.1.1. Any further comment on this paragraph?

(No response.)

FORD: Paragraph 7.1.2 -- I'm sorry.

CARR: Carr, Eagle-Picher. Is there any justification for this tight of a temperature tolerance also?

FORD: Any other comment?

(Laughter.)

I hope, if we get through this section -- we've set a tentative time to adjourn, I believe about five o'clock, that we probably will have time to go back and discuss philosophy and rationale behind some of these statements.

The next comment I have is on 7.1.2. Comment:

"Inasmuch as the most rapid rate of carbonation takes place in the first hours of exposure to the atmosphere, it is recommended that the time permitted to store electrodes in this environment be reduced."

STEMMLE: Stemmle, Goddard Space Flight Center. I call into question that assumption. This past summer I did an experiment wherein I measured the rate of accumulation of carbonation in an open beaker of 30 percent KOH, and it seemed to be rather linear for six weeks. There was no rapid rise that I detected, at all.

At the end of three weeks, in an initially 7.2 normal KOH, we had about 3 normal potassium carbonate.

FORD: Any other comments in regard to that paragraph?

BOGNER: Bogner, JPL. I think you should specify maybe the level of clean room grade, different levels of clean rooms.

FORD: Okay, thank you. Anyone else before we move on?

Paragraph 7.1.3; Comment:

"We presently use a polyamide or teflon sheet to isolate the stack from the can and a filler of similar material to prohibit the vertical movement of the stack within the can."

Another comment:

"In order to produce a cell, other items must be added in addition to the place separator and electrolyte; that is, terminals, combs, ceramics, braze materials, et cetera. I think that this paragraph would serve the purpose better if it put the requirement on the purchaser of the cells to designate the materials he did not wish to have in the cells rather than have the manufacturer, who has the ultimate responsibility for the cell, to have to seek permission for the materials which he has been using for some time."

Is there any additional comment from the floor?

GASTON; Gaston, Grumman. I think it is easier for a manufacturer to supply the material he uses than to specify what you don't want to use. It's a tremendous list.

FORD: Other comments? Okay. We'll move on to the next topic. 7.1.4. I don't have any general comments applicable until I get to paragraph 7.1.4.4. Is there anything that anyone would like to bring up, between those? Yes?

CORBETT: Corbett from Lockheed. I have a comment on 7.1.4.1 and also on what you said about 7.1.3.

I think the danger in for former paragraph is that you specify alkali resistants, which doesn't mean too much as far as what the stuff might do to the cell. That is, you talk about perhaps the material, the resin itself, remains intact and keeps its adhesion, but it may contribute impurities to the cell.

Also, in regard to the comment that you read on foreign materials, I think we certainly do want to exclude all materials except those specified. And I think we do want to require that approval be gotten for other materials. I think that's the whole point of the paragraph -- that you do want to eliminate anything that's really dangerous, and in general I think you ought to eliminate things that you don't know anything about.

So you don't have to know something about them to want to eliminate them, I guess.

FORD: I gather we're talking about a list of specified components that will go into a cell.

FLEISCHER: Have we defined alkali resistant in this specification? I bring this up because in my experience we had a customer to look into the encyclopedia and discovered that Tenite, the plastic made by Eastman Kodak, was alkali resistant. And he used it in a cell. It is not alkali resistant, and it caused us a lot of trouble until we discovered what he was doing.

So I think we're going to have to have a definition for it. We need to 30 percent KOH.

FORD: To answer your question, I'm looking under the definitions under paragraph 1.2.3. I do not see a definition to describe that.

MAURER: I think you need to specify that the alkali will not leach material out of the material in question.

FORD: Is there any other comment before paragraph 7.1.4.4? If not, I'll read the comments I have on that paragraph. Comment:

"Is there a technical justification for having a minimum soak time of 16 hours? If not, this limit leads to delays in processing."

Comments from the floor?

(No response.)

FORD: Paragraph 7.1.4.5. Comment:

FLEISCHER: Excuse me. Did he propose a minimum time of soaking for this?

FORD: No, would you like me to read the statement again?

FLEISCHER: Yes, please.

FORD: "Is there a technical justification for having a minimum soak time of 16 hours? If not, this limit leads to delays in processing."

FLEISCHER: Well the answer to that question is yes. There is a technical reason for this. We can take up hours in explaining it, but the answer to the question is there is.

(Laughter.)

FORD: Okay, we'll return to that if time permits.

Paragraph 7.1.4.5. Comment:

"It is our experience that stainless steel clips will corrode under the formation environment. Since pure nickel clips are not readily available, it is requested that this paragraph include nickel-plated clips."

UCHIYAMA: Uchiyama, JPL. On your last comment there, I believe that is referenced back earlier in 2.4.3.1.5, about the nickel-plated. I think that there's a little inconsistency about the two parts, but it will work itself out.

FORD: Thank you.

The next comment I have is on paragraph 7.2.1.1. Is there any comment from the floor before that?

SULKES: Sulkes, U. S. Army Electronics Command. 7.1.4.7, where you talk about bubbling out and replacement of deionized water. Do you propose that the same electrolyte will be used for multiple formation cycles, or fresh electrolyte should be added -- or you should replace the electrolyte for every formation cycle?

FORD: I don't believe there is any mention made of replacing the electrolyte.

SULKES: Do you feel perhaps this would be a better way to do it?

FORD: Are you asking me for my opinion?

SULKES: Yes.

FORD: I think it would be desirable.

Any other comment before paragraph 7.2.1.1?

GASTON: Gaston, Grumman. Paragraph 7.1.4.6. I feel there should be some requirement how securely these plates are fastened together, should be added. Whether it is by connectors, there should be some minimum resistivity -- either minimum resistivity value, or some specification of how tightly they should be connected.

FORD: Other comments? If not, we'll go on to the next comment that I have. Paragraph 7.2.1.1.

"Edge coating of plates should be allowed."

Comments from the floor?

GASTON: Gaston, Grumman. Edge coating could lead to problems. If it's allowed it has to be carefully considered in the material used, and how well it adheres and how well it adheres later on.

I've seen a failure mode to edge coating.

FORD: Other comments?

REED: Reed, Battelle. 7.2.1, about coining plates. If we go back here to 2.1.1.1.9 we've already decided that the plaques should be coined prior to impregnation. So I wonder what is meant by this paragraph 7.2.1?

FORD: I would think there's a redundancy in the two paragraphs.

The next comment I have is on paragraph 7.2.2.3. Does anyone from the floor have comments on paragraphs leading up to that particular one?

CARR: Carr, Eagle-Picher. With regard to 7.2.2.2, I don't believe we can cover all contingencies for sample plates. I think it's like the color standards. I don't think you can set up standards by showing things like this.

I think this was attempted on soldering, and they found it very difficult to, by samples or pictures of solder joints, to show good and bad. There's always something that falls in between someplace.

FORD: Other comments?

(No response.)

Comment on 7.2.2.3:

"With previous sorting as recommended by us, the allowable rejection rate should be significantly reduced."

Second comment:

"Because of the stringency of this specification, it is expected that more than 10 percent of plates could be rejected. However, with sufficient 100 percent inspection, and all subsequent testing which follows, the customer should be assured that he does get a reliable product. We, therefore, take exception to this paragraph whereby total spirals can be rejected."

RICHARDSON: Richardson, Marshall. I notice you've put a flat 10 percent. Would it be better to use a MILSTANDARD 105.D., depending on the total quantity of plates? Some manufacturers might build 3,000 plates, or something -- a given lot, and another manufacturer may only build 100. And your MILSTANDARD would take care of your lot size, in lieu of a flat 10 percent across the board.

FORD: Okay.

CARR: Carr, Eagle-Picher. Again, I would like to recommend that an action such as material review board authority be considered before indiscriminately throwing away lots of material.

HALPERT: It seems to me that if this material can be used, in fact, in a commercial cell, I don't see why they -- they'd probably be good for commercial -- we just want to make sure they're high quality in terms of aerospace.

CARR: Eagle-Picher does not manufacture commercial cells.

(Laughter.)

FORD: Anyone else care to comment?

CORBETT: Corbett from Lockheed. This is not directly on the matter at hand, but since Earl has brought up the point of a material review board a couple of times, my experience with organizations of this type, and quality assurance organizations in general, is that what happens when you have a particular technical problem is that the guy from MRB or the guy from whatever QA organization it is, eventually comes to the battery guy or the solar array guy or whoever it is and says, "What should I do? Should I reject it or should I buy it, or what?"

So these people are not technical specialists. They're just people who are paper shufflers, who are charged with the responsibility of handling a particular problem.

(Laughter.)

And I just don't think that that's really solving the problem, to give it to the MRB, you know. It's a way of buying off a bunch of plates that you might want to hold onto, but that's about it.

CARR: Carr of Eagle-Picher. Bob, the purpose of MRB is not just to guy off material, but it's to very definitely assign a corrective action and the procedures you're going to follow from thence on.

But just because 10 percent of the plaques may have a let's say what actually may be a minor problem, doesn't mean -- and let's say that the lot can be screened 100 percent -- and the other 90 percent does not, does not mean we should throw the plates away.

RICHARDSON: Richardson, Marshall. That 7.2.2.3 there which says -- it refers to 7.2.2.4 -- and if you look through the a,b,c,d,e there, these are visual inspection types of things here. And really, what you're really talking about, to 100 percent, you want to inspect all plates. And in essence here, for the surface type defects and visual defects, that you cited in 7.2.2.4; so here again, you're going to wind up with a batch of good plates and a batch of scrap plates, really. Because there isn't any -- in essence you don't have any MRB if you've got all these cracks and nicks in the edges. They're bad plates, and there probably wouldn't be any MRB to accept or reject the bad ones. But maybe you'd want to come up with a change in the process or something of this nature, to maybe why you're getting a lot of blisters, or why you're getting a lot of cracks, or something like this.

CARR: Carr, Eagle-Picher. Right, John, I agree. That's the purpose of MRB, is to assign a qualified team of engineering, production and quality personnel, to analyze what the problem really is.

RICHARDSON: Right, but in material review action there's always a "use as is" disposition as one of the alternatives. And obviously it would not apply in a case of defective plates.

CARR: Right. But we're discussion this provision which says that if you've screened through the plates and you've got 10 percent of them that have got bad edges, it says throw them all away. And I disagree with that.

FORD: Okay, Earl. I think your point is taken. One comment I might make along these lines in regard to a material review board is that usually, or in most cases that I have been aware of, you're faced with a production schedule at the same time as you're faced with a material review board. And I can tell you, they're not always compatible.

SCOTT: Scott from TRW. Floyd, I was just comparing that paragraph that we were talking about, 7.2.2.3, with paragraph 2.4.2.6, which establishes acceptance level on a lot basis for a spiral. And I don't know right now quite why we are still accepting -- we're still applying lot rejection criteria in section 7, having already done it in section 2. I think those may be not compatible. You may want to take a look at that.

FORD: Okay. Other comments before we move on to the next paragraph?

(No response.)

Paragraph 7.2.2.4. Comment:

"The following is recommended in place of this paragraph as being more realistic and practical:

'1.0 After completion of cutting plaques to plate size, or prior to assembly into a formation pack, a 100 percent inspection will be performed on positive and negative plates using the following criteria as a basis for rejection:

1. A crack in the sinter exceeding 1/2 inch in length on both sides of the plate will be cause for rejection.

2. A crack on either side of the plate exceeding

three inches in length and two inches in width will be cause for rejection.

(Laughter.)

VOICE: That doesn't make sense. It sounds like a --

FORD: Let me read that one again to make sure I didn't --

(Laughter.)

"2. A crack on either side of the plate exceeding three inches in length and two inches in width will be cause for rejection."

(Simultaneous conversation and laughter.)

FORD: All right. I'd like to read over all of these before I ask any comments, if I may.

"3. Intersecting cracks will be cause for rejection.

"4. Parallel cracks within the pitch of one hole pattern.

"5. A crack, regardless of size, that gives evidence of flaking will be cause for rejection.

"6. Rough edges, burrs and snags exceeding 0.001 inch. This inspection will be made with nylon gloves to feel for pulls on the fibers of the gloves. Inspection will include the entire electrode surface.

"7. If pimples or blisters are 0.002 inches above the electrode surface or the sinter material

is breaking away from the grid, the plate
will be rejected."

At any time while I'm reading this, if you want me to go back, please stop me at that point, and I'll re-read it.

"8. Tabs will be free of sinter material.

"9. Coining of edges will be a minimum of 0.015 inch.

"10. Plates will be of uniform thickness over the entire surface area (plus or minus 0.002 inches). A 10 percent random sample will be selected for thickness determination. If all samples can meet this thickness requirement, then all plates are acceptable. If one or more plates from this sample cannot meet this thickness requirement, then 100 percent inspection will be performed to eliminate plates which do not meet this requirement."

That concludes the comment. Now I'll open the floor for comments.

RICHARDSON: Richardson, Marshall. Let me ask one question here. Does any -- does this actually get measured, actually go on and measure each plate for 1 mil cracks, width, or anything? That's in 1 mil thick? On a 100 percent basis? A crack that's -- and also on the length, okay. Wait a minute, there's rough edges and burrs, half a mil -- I don't know, I'm asking the question -- how do you measure this? I don't know of any -- this would be an extremely time-consuming process to me, to do this, on a 100 percent basis. I don't know how you could do it, without a lot of shadowgraph or something like this, inspecting them individually.

HERZLICH: Herzlich, Sonotone. My remarks are with regard to blisters. I believe that no blisters should be allowed.

GREEN: Green, Martin. I notice one thing in here, that in both the comment and in here, that we are attempting to do something real exotic here, in inspecting these, and now we're getting into the fact that we're depending on the human feel.

I think possibly that something could be done about that, into some method that eliminates the human element. This feeling with gloves, nylon gloves in particular, has not proven to be anything more than to tell you it's there. It doesn't tell you how much or why. And I think some other means should be thought of in the finalization of this, to come up with some good mechanical means.

FORD: Other comments from the floor regarding that paragraph?

(No response.)

The next paragraph, 7.3. As you are aware, it alludes to two methods to be used for plate identification and cell serial numbering.

Okay, comment on paragraph 7.3:

"Method A results in excessive losses due to the fact that the formation pack must have the same number of plates as the cell, and a single plate rejection during formation necessitates the rejection of the remaining good plates; this is rejection by association."

Second comment:

"We use and recommend a method somewhat different from either of those proposed. The formation is conducted as outlined in 'B'; however, in assembline the positive and negative cell stacks, the plates are selected according to weight and thickness in order to arrive at uniform stack assemblies. These assemblies then remain fixed for all the following tests."

Any comments from the floor?

CARR: Carr, Eagle-Picher. We don't form in any of these ways. We perform a formation stop before we build our cells, but we do an added formation step in the cell itself. And we would like for this to be considered.

FORD: Other comments?

FLEISCHER: I didn't understand the last remark. You mean you do not have a formation of the plates before you assemble them in the final cell?

CARR: If you're talking about the balance of the positive capacity versus the negative capacity, this we set finally in the cell itself, rather than setting the balance of precharge or whatever you want to call it, the discharged negative capacity against the charged negative capacity, we do that in the cell itself.

We do a formation step before that, but it's merely, in essence, a cycle, rather than a formation as is used here in the specification.

FORD: Other questions?

SCOTT: Scott, TRW. In the comment that was read, there was a term -- the business about matching positives and negatives -- positive and negative plates by weight and thickness -- in order to arrive at a uniform stack assembly.

I don't know -- I'd like to know what uniformity -- how the term "uniformity" is being used there. Are you talking about thickness, compression, capacity, or what?

FORD: I won't call out the specific people that made the comment. If they feel free to do so now, they may. If not, we'll pass the question on for later clarification.

SULKES: Sulkes, U. S. Army Electronics Command. In your Method B,where you form cell packs and then break them up, you do have end plates which do have different charges put into them,than the rest of the plates. These then are distributed in an uneven manner throughout the batteries when these packs are broken up.

Would you feel that it would be advisable to have the end plates removed and discarded?

HERZLICH: Herzlich, Sonotone. We find that thickness and weight offers only very very poor correlation in terms of matching. And the successful methods that we suggest include a capacity test of each plate. And matching the plates according to their individual capacity.

FORD: I think this morning that the gentleman from Sonotone mentioned -- this is what you're talking about -- you prefer the 100 percent capacity measurement on every plate?

HERZLICH: On each plate.

FORD: On each plate.

HERZLICH: And then bring them together in a matched cell.

BELOVE: Belove, Sonotone. There's one other thought in this, along this line. And that is, many of us have seen and heard of the effect -- that nickel-cadmium cells and the plates of nickel-cadmium cells appear to have some sort of a memory. That is, they react in the future in part in accordance with how they've been treated in the past. In other words, they -- a variation in charging regimen or discharging regimen may alter their performance on future work.

We believe in this case, then, that all cells -- all plates should be tested and that Martin Sulkes, as he mentioned before, the end plates, we believe that these plates are being tested differently than the others, and this is one of the reasons that we say all plates should be tested individually, rather than in cell packs, where you do have end plates, that will be tested or subjected to a regimen that is slightly different than the internal plates. And this difference may turn up later in cell performance.

RAMPEL: Rample, General Electric. I'd like to clarify something that Martin Sulkes said before, about the end plates, also. And I feel that whether or not they should be discarded depends on the last discharge, the final discharge.

SULKES: Sulkes, U. S. Army Electronics Command. Basically, they don't necessarily have to be discharged, but the way method B is set up, they're allowed to be mixed in and you could end up with 4 or 5 of them in one battery. And since they do have a different characteric, this could cause a problem and non-uniformity.

PREUSSE: Preusse, Gulton. I'd just like to offer something to confound some of these statements, but not offer any explanation for performance. We deliberately manufactured a cell with negative electrodes, wholly made of end plates in formation, and put them through the process with cells in which end plates were interspersed in the cells. And in our 18 days of acceptance testing, in the process we found no significant difference, statistically, at the capacity, over charge voltage or pressures in the cell at all.

That's for interest purposes.

FORD: Other comments? My next comment is on paragraph 7.4. Therefore, if anyone from the floor has any comments on method A and method B, it's open for discussion at this time.

I might comment that we are very interested in looking at the method where plate identity is established and maintained throughout the life of the cell. There appears to be some justification in maintaining traceability from day 1 on the plate group all the way to the end of life performance.

Comment 7.4. Lou Belove:

> "The testing of plates in formation packs is considered to provide 'average' results. For space applications, plates tested as individuals provide the basis for maximizing cell uniformity and overcharge capability."

And I believe you had a comment you wanted to make from the floor?

BELOVE: No, I'm passing up the comments because it would merely be redundant. It's been repeated and repeated.

FORD: Okay. The next comment I have is on paragraph 7.4.2(d). Are there any comments before that, from the floor?

SULKES: Sulkes, U. S. Army Electronics Command. One basic philosophy I think that perhaps should be brought up is either you do individual plates, which certainly gives you a bigger advantage, or you might just as well build these packs right into the cells and do your work there.

Since you really end up with the same result, you save an awful lot of handling. And the cost, let's say, of putting it in the cases is not as much as all this extra work that you're going through here. You just might as well reject them in a cell, if they're bad.

CORBETT: Corbett from Lockheed. Floyd, I'd like to ask what you meant by 7.4.2.(b). I don't quite understand what that paragraph means there.

FORD: You want me to interpret that?

CORBETT: Yes.

FORD: I'll read that statement:

"The volume of KOH contained in the formation container shall be equal to or greater than the volume displaced by the cell pack."

In other words, you want sufficient KOH in the container -- you have twice the volume of the cell pack of KOH in the container.

CORBETT: So the volume of the tank really has to be twice as big as the total --

FORD: Right. Any other questions?

The comment on 7.4.2(g) -- I'm sorry -- 7.4.2(d): "We are not sure that this is at all possible, because of the proximity of formation cases, and the fact that some out-gassing may occur with the expected entrainment of electrolyte. I think the practicality of obtaining the required resistance must be demonstrated under practical conditions before this paragraph becomes a rigid part of the specification."

I'll read the other comments I have in regard to 7.2.2. I have one on paragraph (g):

"The tolerance of plus or minus minutes does not have any technical justification. A tolerance of plus or minus one hour in a 24-hour charge would hardly be significant, and it would be difficult to justify rejecting a formation because the overcharge ran for 24 hours plus three minutes. Although we recognize the need for tight controls, they must at the same time be reasonable. We would recommend that a percentage of time, that is, plus or minus 4 or 5 percent, be considered."

The next comment I have is on paragraph (h):

"It is requested that the tolerance be extended to plus or minus 2 percent, and that this figure is reasonable from both a practical and technical standpoint."

The next comment I have is on paragraph (i):

"Since Section (h) of this paragraph practically dictates individual power supplies if these supplies are in effect isolated from one another then the 2 meter system is redundant. We therefore propose that in those cases where those individual isolated power supplies are used, 1 meter be considered sufficient."

That concludes my comments on paragraph 7.4.2(a) through (k). It's open to discussion from the floor.

MAURER: I'd like to say that we should put something in on how the voltage should be measured, and at what point; because of errors that can creep in because of the voltage drop in leads the voltage reading point should be as near to the cell plates as practicable.

FORD: Okay. I think we get into that in the next paragraph; however, I don't believe it specified -- that there's any reference made to lead drop, or exactly at what point the voltage should be picked up.

The next paragraph, 7.4. --

SULKES: Floyd, I've got one. Sulkes, U. S. Army Electronics Command. Basically, after you've gone through all this trouble and all this expense, you're using awfully sloppy meters and basically not taking the data -- where now it's getting to where you've put all this expense into it -- in other words, 1/2 percent meters are not uncommon, and I think in all our Army specifications we use plus or minus 1/2 percent meters. The same thing on the difference between two meters. Here again you shouldn't allow plus or minus two percent on the voltage, which is (j). It would appear that actually this probably should be continuously recorded. And I think there is certainly equipment available nowadays that can do this fairly easily and inexpensively.

FORD: Other comments on that paragraph?

(No response.)

Paragraph 7.4.3. Comment:

"We take exception to this paragraph for a number of reasons:

(a) The method of resistive loading of the cells results in the continued discharge of the positive between 0.5 volt and 0.0 volt. Because of voltage regulation requirements, this positive capacity is unavailable to the cell user. At the same time, that this positive capacity is being reduced, available negative capacity is also being diminished and becomes unavailable in the ratio tests.

In the case of a 20 ampere-hour cell, we have found that we obtained approximately 28 ampere-hours positive capacity to the half volt end point, and an additional 8 ampere-hours when we one ohm to 0.0 volts end point, and a total measure negative capacity of 42 ampere-hours.

When we compute the ratios if we base it on the resistive loading technique, we end up with a ratio of 1.2 to 1. However, if we computed it by determining positive capacity to 0.5 volt we obtain a ratio of 1.5 to

Again, since the positive capacity obtained between 0.5 volt and 0.0 volt is for all practical purposes unavailable to the cell user, it should not really be considered as a factor in determining the cell's performance.

(b) It has also been our experience that the -0.2 volt is arbitrary and does not necessarily represent the failure of the negative, therefore, we would request that this value be changed to -1.0 volt."

That's all the comments I have on that paragraph. It's open to discussion from the floor.

CORBETT: Is this the whole paragraph now?

FORD: Yes, we're now talking about paragraph 7.4.3 in general.

CORBETT: Okay. Corbett from Lockheed. I think paragraph (d) is kind of a sensitive one for me, because you're talking about a percentage of the manufacturer's rated ampere-hour capacity. And I think different manufacturers for different sized cells and for different projects have a different idea of how much excess capacity you have to built into these cells. And if there's anything that this kind of specification achieves, I would hope it would be a standardization of the capacity of the cell, and the active material that's in the cell, compared to the rated capacity of it.

BELOVE: Belove, Sonotone. I believe that in order to make this meaningful, the rates used for charge and discharge should approximate as much -- as closely as possible -- the actual -- and the voltage, incidentally, should approximate the end use as closely as possible; otherwise, I do not believe this is meaningful. It's an approximation, but it does not come close to what will actually be obtained in cell or battery usage. That goes for the -- for example, discharging down to .5 volts. Well, we have seen cases, and I think most have seen this, where some cells will last longer than others to any given voltage, however, a different voltage level.

Now, if you are interested in providing a family of cells in a battery, and thereby provide long battery life, you must then know the voltage as you go along, and it must be usable voltage.

RAMPEL: Rampel, General Electric. With reference to the negative/positive ratio to plus 1/2 volt, and comparing it to the negative/positive ratio at 0 volts, I would like to mention that one may obtain a low ratio at 0 volts, down to 0 volts, but we have to consider the fact that when one is charging a sealed cell at cold temperatures, such as 32 degrees F., the charge efficiency of the positive is close to 100 percent, and so that will be the true ratio down to those temperatures.

HERZLICH: Herzlich, Sonotone. We believe that the 1.2 to 1.3 to 1 ratio is ill-advised, and would like to recommend 1.75 to 1 as a minimum.

FORD: May I clarify a point here? I don't think that's intended to be a ratio, if you're looking at paragraph (d). The ampere-hour capacity of the positive plates, as determined in paragraph (b) above, shall be a minimum of 1.2 to a maximum of 1.3 times the manufacturer's rated ampere-hour capacity. Okay?

CORBETT: He's talking about paragraph (g), though.

FORD: Oh, I'm sorry.

CORBETT: Where it also said 1.3.

SULKES: Sulkes, U.S.A. ECOM. In (g), it's 1.3 plus or minus 0.5. Does that mean the ratio is from .8 to 1.8?

VOICE: No, that's .05.

SULKES: Oh, okay.

FORD: Let me point out one further thing. That you're not determining the total negative capacity in paragraph (g). You're determining the minimum acceptable capacity at that point. It may be in excess of that.

RUBIN: Rubin, from Texas Instruments. A question to the gentleman from Sonotone is why he thinks the negative to positive ratio should be that high? Is there any technical support for that? Has Sonotone ever looked to the effect of pore volume filling, or the effect of cadmium loading and plate thickness? On the effects of over pressure?

There is quite a bit of data that I believe was published in the power sources conference when it was conducted in 1967, that shows high electrolyte fill as well as high cadmium loading can effectively stifle oxygen recombination rate.

And also, a heavily loaded cadmium pore will tend to block and fade much more rapidly than a more lightly loaded one.

PREUSSE: Preusse from Gulton. I think that there is also a hypothesis that the oxygen recombination characteristics are based on the number of active nickelcytes, and not on the negative capacity available in a cell. And if there's any question, I wonder whether Dr. Seiger can expand on it -- can substantiate it.

SEIGER; I think there are about five manufacturers of nickel-cadmium cells here, and each one uses their own method in obtaining characteristics. Some may want to use a ratio of 1.3 or thereabouts; others may want a larger ratio of 1.7 or greater.

All of these depend upon how they want to design the cell and what they want the cell to do. It also depends upon what the cell does as it ages. As well as the conditions-- the rates, and the temperatures under which the cells are used. I believe if we went to volume III of last year's meeting --

the minutes of last year's meeting, you would see that we had this particular aspect brought up. As a matter of fact, it was Jim Dunlap who asked the question I had given a particular answer still holds.

I could give an answer of what I want, or how I want to design the aerospace cells that would perform. I'm sure that Ed Rubin has another answer for his plates; Rampel has another for his, and Herzlich another for his. And we want to consider all these things.

We're dealing with five different manufacturers -- not with one spec, really. But what should come out of this is what is the best way that each one should make their plates.

FORD: Thank you.

RAMPEL: Rampel, General Electric. With regard to ratio in general, whether it be 1.2 or 1.3, the need for higher negative to positive ratios is really a necessity to provide varying degrees of precharging of the negative.

HALPERT: On that number 1.30 plus or minus 0.5, we're looking, as you said, for a minimum negative/positive ratio. Why would we want to -- and what you want to consider is why we need a plus or minus on it. If we want 1.3 that should be the minumum. We wouldn't want 1.3 plus or minus anything.

In other words, it can be plus anything, but the minimum should be 1.3 or 1.25, whichever is decided on.

FORD: I think, if you'll read it again, it's 1.3 plus or minus .05 times the positive plate capacity. It just gives you a tolerance in multiplying your numbers out. But a minimum of 1.3 is what really is being asked for.

Other comments?

GROSS: The objective of the specification is to obtain long-life batteries; long-life I believe is ample test data that shows that long-life is promoted by operation at low temperatures. And so, therefore, we would like to operate batteries at low temperatures. At low temperatures, however, the negative plates have lower efficiency, and one would expect, therefore, to require a larger amount of negative plate material.

FORD: Other comments?

(No response.)

I see it's about four minutes after five. I think we're at a fairly good point to break. If there's no objection at this point from any of the other Committee members, I think we'll start off in the morning at nine o'clock at paragraph 7.4.4, "Wash, Rinse, Drying Plates."

I'd like to thank you for attending today, and especially thank you for taking part in the meeting; because, after all, you're the people who are going to make this spec work.

(Whereupon, at 5:05 p.m., the meeting was adjourned, to reconvene at nine o'clock a.m., Friday, October 31, 1969.)

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS

Building Number 3
Goddard Space Flight Center
Greenbelt, Maryland

Thursday, 30 October 1969

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P R O C E E D I N G S

HALPERT: I just have a couple of quick comments. There were two briefcases left in here overnight, and they were taken out to the guard house and they have been returned. If you are missing a briefcase, you can claim it I guess come see me and I will see if I can find them. They're in the back of the room somewhere.

Second, if you haven't signed the roster, please make sure you do so to receive a copy of these comments of the meeting. If there is anybody who came in today who does not have a copy of the specifications, we have copies here which I will be glad to pass out to you. Is there anybody who does not have a copy of the specs this morning.

Okay, I guess we'll go back to number seven and Floyd Ford.

FORD: Good morning. Before I get started I would like to reiterate a point that was made yesterday. The purpose of the microphones that are being handed to you is to facilitate the recording of your voice, so that the reporter down here can use these tapes to fill in any place that may be void in his records. So, this morning when you want to make a comment just indicate by raising your hand, and the gentleman on the right or left aisle will hand you the microphone. And if it takes a couple of seconds to get it, we'll wait until you have the microphone in your hand. But it is really for everyone's benefit because I would like to know that everyone's comment does get recorded.

We are on paragraph 7.4.4.

Comment: From the point of view of carbonation, we recommend drying under vacuum rather than in circulating air for 24 hours. Are there any comments in regard to 7.4.4?

FLEISCHER: I'd like to make a comment on that. I'm sort of surprised that the engineers will allow that commend to stand, because what you do in a vacuum is you have heat transfer problems, so that unless you have a circulating gas you're in troubles. And the equipment that you need will go way up in size.

So, you are trading off dollars here. It is much better if you have a circulating gas, and it would be better actually if you are worried about CO_2 to take it out.

FORD: The next comment I have in on paragraph 7.4.4.2. Is there any comment leading up to that paragraph?

Comment on 7.4.4.2: We should like the technical justification for the 55°C limit on drying of plates. That's all the comment. Are there comments from the floor on that paragraph?

rms 3

MAUREP· Do the negative plates at this time have a state of charge adjusted, and do we really want to dry charge negatives in air at 55°?

FORD: According to the previous paragraphs the negatives may have some charge. I say "may." And most probably they will.

The next written comment I have is on paragraph 7.4.6(a). Would anyone care to comment on paragraphs leading up to that paragraph?

Comment up to that paragraph, from the floor?

(No response.)

This is going to be a slow morning.

Comment: The applicable portions of MIL-W-8611 should be defined. There are some provisions in that specification which are not at all practical. A comment in regard to (b) of that paragraph: We question the technical justification for the plus or minus .003 inches alignment tolerance.

Okay, are there comments from the floor?

FLEISCHER: I notice in some of these suggestions it says that in this one there is no justification, or what is the justification for one percent, but no suggestion was made as to what is considered to be a reasonable figure. And I don't see how the members of the panel who wrote this specification could have access to all of the information

rms 4

which decides on what a percentage figure should be, and I think the suggestion should be made we think that this tolerance should be five percent or seven percent or whatever is considered to be a reasonable manufacturing tolerance.

FORD: Other comments?

GASTON: Gaston, Grumman.

I would suggest than an alignment fixture be used so you would get a close enough tolerance or very close tolerance in the alignment of the plates.

FORD: One comment I might make even though this is not a third electrode spec, this tolerance of alignment of plates, particularly in certain types of third electrode designs is most critical to present shorting of the third electrode, which will be covered in a third electrode spec.

Okay, the next comment I have written is in paragraph 7.4.8. I would entertain comments between those.

RICHARDSON: Rick Richardson, Marshall. In 747 I would recommend you add a similar paragraph as you have in (d) in 746, "inspect for loose particles and materials when you're wrapping the plate stack." We have seen indications in the past where you get extraneous particles on the plates which become embedded and possibly after vibration or after considerable use you could get a short in there.

I think this ought to be 100 percent final inspection

rms 5

there, when you are wrapping the plates, inspect for any loose particles or extraneous material.

FORD: Would you care to comment on what type of particles you are referring to?

RICHARDSON: Pieces of silver. We've seen silver solder, occasionally, expulsion particles from weld tabs from the third electrode to a tab that would get embedded in the separator, Okay?

FORD: Yes.

RUBIN: Rubin, TI.

If it is the intent of the spec to have the operations listed in 7.4.6 and 7.4.7 to be sequential operations, then I recommend that the manufacturer have the option to do these in their own order of operation since there are advantages to wrapping a plate stack with a separator prior to welding. For example, bending of tabs back and forth, this also does disturb the alignment.

One comment on the alignment, plus or minus 5000ths is probably a better number.

FORD: Would you bring the microphone down here. We have a comment in the front.

GASTON: Gaston, Grumman.

I would like to give an additional comment to the gentleman from Huntsville. I agree, yes, particles can be found and we have found nickel particles in the separator

rms 6

embedded. And the inspection for loose particles is very important. And it is a possible failure mode.

FORD: I guess I'm kind of curious on whether particles are in the separator to start with or whether they are coming from the handling of the separator, et cetera.

RICHARDSON: Richardson, Marshall.

Here again maybe some of the battery manufacturers may elect to wrap the plate stack first prior to welding the combs of the tabs, and here again you'd want to provide some protection of the plate stack on top of it in case you got anyexpulsion particles again when you're welding plate tabs in the comb.

And what was that other question of yours now.

FORD: I was just curious as to where the problem with particles in the separator is identified with particles in the separator before it is ever used or actually in using it to put it in the cell, these particles got into the separator.

RICHARDSON: No, they were not embedded in the separator. In other words, they were relatively large particles that would be extraneous to the separator. They are not really small -- in other words, embedded in the Pellon or something like that?

FORD: Yes.

RICHARDSON: No. To my knowledge we haven't found

rms 7

anything like that, small particles embedded in the Pellon. I guess it is possible you could find something in there.

FORD: Other comments before we get to paragraph 7.4.8? Last call.

(No response.)

Comment regarding paragraph 7.4.8: We take exception to that section of that paragraph that calls for a total rejection with no retest allowable. It is possible for cells to fail the short test because of moisture, and it is therefore common to allow at least for air or vacuum drying of the stack.

If in fact the cells fail because of faulty separator, we see no reason why the cell should not be rewrapped and then retested. We see no problem generated by rework at this point.

Comments are open for the floor.

MAURER: If the short occurred because of a very fine particle in one of the plates poking through the separator, a rewrap may fortuitously avoid that short the second time, and it would reappear after a slight amount of shock and vibration. So, I would vote for leaving that rejection in.

GASTON: Gaston, Grumman.

In the present OAO cell specification we permit one rework cycle, so permitting one rewrap providing records are kept, but a maximum of one rework cycle.

FLEISCHER: Reference was made in the objection that there was moisture present, and it isn't clear where the moisture comes from.

Number two is that some of the manufacturers just said that they wrap first and then do their welding and this would show up I take it after the welding.

FORD: Yes.

FLEISCHER: So, now, you are going to rework this group, spreading the plates apart.

FORD: Yes, that's sort of the question. And the comment does not allude to that, or no one else had made a comment in regards to if you have the tabs welded up then the concern I think would be in the flexing of the tabs to some extent to reweave the separator. And in some cases though this test may be run before the weld is made in which case a rework would be practical.

FLEISCHER: Well, I just wanted to bring out these points that the procedure may have something to do with what is allowable and what is not.

FORD: Other comments from the floor?

SCOTT: Scott from TRW.

I suggest that maybe this requirement of a hundred megohms resistance be looked at and possibly adjusted to resolve the difference between the effective

rms 9

moisture and the effective other shorting particles. I suspect that a reasonable value could be much lower resistance than that. So, I think that resistance requirement there should be looked at before this thing is resolved.

FORD: Other comments?

SULKES: Sulkes, U.S. Army Electronics Command.

There is no provision here that says they can't run a precheck of this very test before welding is made which in effect would allow a rework. In other words, they can do it before if they want to.. The other thing, I believe you do specify certain humidity limits which probably would hold you to this value and you shouldn't have that problem.

Since you know what the test is your manufacturing procedure should be set so that you don't run into problems with it.

FORD: Other comments?

SCOTT: One more. I don't feel that we know enough about the absolute value of completely dry separators at this point. And if some degree of moisture in the separator is no problem and that degree of moisture gives less than 100 megohms, I think we're on the wrong track. Just the fact that the separator has some water content isn't necessarily bad at this point.

rms 10

FORD: Anyone else?

FLEISCHER: Your remark about the resistance of the separator, as I recall, if you take a sheet of cellophane which has been preserved properly under the right humidity and temperature controls that are recommended by duPont and you measure the resistance Megger, you get up to infinite resistance, so that the separator shouldn't be a problem here in determing this.

I think your 100 megohms is a suitable figure. I could have been infinity.

FORD: I might point out that we also are talking about Pellon or the woven -- nonwoven(?) Nylon. You mentioned cellophane --

FLEISCHER: WEll, that's the one I had measured.

FORD: Okay.

HALPERT: These plates are put together -- prepared to put together in the cell -- they are clamped together in such a manner as to fit into the can or slide into the can properly. And if you have a plus or minus 2 mil -- what we're asking for is plus or minus 1 mil -- but even that's a 20 mil variation. If you have to squeeze the plates by that difference in 20 mils, you can get almost any resistance variation between the -- even in a Megger reading. It is not infinity. And it varies all over the lot I would say.

rms 11

FLEISCHER: You mean lower than a hundred meg-ohms?

HALPERT: It can go lower or greater. If there are no short problems, and if the separator does not -- I don't know what the effect of humidity is, but if there are no short problems, I would expect it to be greater than 100 megohms. So that number is a reasonable number, but I don't think it would be infinity, because of the fact that we're getting closer and closer, and you may really be close enough in terms of distance where there is maybe reasonable resistance. It's in the breakdown of the actual materials.

FLEISCHER: WEll, I'm satisfied that a hundred is a reasonable figure.

FORD: Are there other comments?

GROSS: Gross, Boeing.

One of the important objectives of the specification is to obtain uniform, consistent processes by the manufacturers. I don't think that this is the time to include waivers in the specification.

When the manufacturer finds that something is wrong, not passing the short test, for example, then there is something wrong with the process. And this should happen once or twice and it should be straightened out. And it shouldn't happen again.

rms 12

FORD: I see no other hands, so I assume that's all the comments. So, we'll move on to paragraph 7.4.9.

Comment: A weight gain within plus or minus three percent appears to be high considering that the electrolyte can be filled to within plus or minus 0.1 cc.

I have no other comments until I get to paragraph 7.4.9.5.

MAURER: I have a comment. We haven't gotten the plate stack into the can yet at this point.

FORD: Okay. It apparently is out of place, but it applies in this paragraph. That is a good point.

NIETZEL: Nietzel, TI.

This is a specification and not a process outline, so I don't see any problem there.

SCOTT: Scott, TRW.

If indeed the provision for X-raying the cells after final assembly is to stand, which appears further down the line, it may be advisable to also X-ray at the point before the cover is welded onto the can in order that if any kind of rework is to be considered this is the time to do it on the basis of possible defects that might show up during the X-raying rather than after the can has been welded and shut.

I don't know exactly where that should come in here, because it isn't clear in going through the test requirements here where the cover actually gets welded on.

FORD: Are there other comments?

REED: Reed, BAttelle.

In paragraph 7.4.9.3 it calls for the use of an automatic buret to prevent contamination of KOH, I assume by CO_2, all of the automatic burets that I know of are glass. And, of course, we know that glass and 30 percent KOH are not too compatible, so I would throw this out as sort of a general question. Does anyone know of a plastic automatic buret on the market?

NIETZEL: You can end up manufacturing one yourself, an automatic buret, stainless steel 304L, no problem at all.

REED: Do any of the manufacturers use such a device, or what sort of buret are they using to fill at the moment?

NIETZEL: Yes, TI does use such type of buret.

FORD: Other comments?

(No response.)

Okay, if not, we will move on to 7.4.9.5.

Comment: We see no technical justification for a three-minute limit after the filling operation. The same comment applies to the three-minute limit after the installation of the gage assembly. If there are some

rms 14

controlled experimental results we should be made aware of them.

The floor is open for comments.

(No response.)

Okay, the next comment I have is on 7.4.10.1(a).

The pressure of 0.0 plus or minus 2.0 psig appears to be an error.

Another comment in regard to paragraph 7.4.10.1: WE would like to know the technical justification of the one-hour limit after cell filling. The cell has already been gaged and evacuated. It is also mentioned in this paragraph that any indication of a leak is sufficient reason for cell being rejected. We suggest that this should read, "any confirmed leak."

Are there any comments in regard to that paragraph? That's all the written comments I have regarding chapter seven.

MAURER: I have a comment with respect to part (c) "Leak rate shall be less than 10^{-5}." All of the other tests of the sealed components were 10^{-8}.

HERZLICH: I believe 7.4.10.1 (g) should be altered to read, "A minimum of 16 hours shall elapse between the filling operation and the beginning of the first charge on the cell." The word "beginning" is not in the present text.

rms 15

CARR: Carr of Eagle-Picher.

With reference to Dr. Maurer's comment regarding leak rate, we use the figure 10^{-7} as accpetance criteria. But normally we find that the cells pass 10^{-10}.

RUBIN: Rubin, TI.

I question the necessity for the minimum of a 16-hour cell. I think that should be the manufacturer's option. There are techniques which allow you to charge immediately after filling.

FORD: I believe that same question in some of the comments came up yesterday in regard to the filling. I think we may get into that this morning.

As I said, I have no further comments, specific comments, in regard to chapter 7. At this time I'd like to open the discussion for general comments in regard to this chapter, if anyone would care to make them -- philosophical type comments, et cetera.

SULKES: Sulkes, U.S. Army Electronics Command.

I don't find any place where the state of charge of the cadmium is adjusted. Have I missed something?

FORD: No, you did not. It is not in here at this point. It will be included.

SULKES: Once you've pinched off the tube, you've had it.

FORD: Agreed.

rms 16

BOGNER: Bogner, JPL.

A couple of comments concerning the electrolyte fill. I don't know if anyone has established how much carbonate you can stand in the cell, but maybe this operation should be carried out in the glovebox to eliminate all possible contamination from CO_2. And I haven't seen anything in the specification that says how the KOH should be stored. I think it's initially mixed up when you measure the CO_2. And from there on in nothing is said how it's stored or how it's handled, and I think I've seen some instances where it can be exposed to the atmosphere.

HALPERT: I would like to make a comment with regard to Sid Gross' comment earlier, and that is somebody made the statement yesterday that they were testing the hell out of these plates and cells, and I can't -- since we are doing quite a bit of testing on these materials to make sure they are reliable and to make sure they meet a certain quality, if we run into a problem with shorting or any other problem, I don't see why we just don't put them aside.

Why bother to rework them? Are the materials that expensive where we can't do it? Or can they not be used in some other application by Aerospace? I don't see the reason for continuing to work with something that is shown to be not within the proper tolerances that we're

rms 17

trying to show here. Maybe I can get some further comment from others.

GROSS: I want to put them aside and then straighten out the process, so it will never happen again. There's something wrong for that to have happened.

RAMPEL: Rampel, General Electric. 7.4.10.1 (b). After you put KOH in the cell it would be extremely difficult to check the cell for a leak rate. It would be difficult to pump it down with that KOH in there.

FORD: This is a cell with a gage assembly. Supposedly this cell is sealed. I am not sure I follow the logic behind your comment.

VOYENTZIE: Voyentzie, GE.

I think the thing is here with the valve on it you would face helium hang-up. And if you're trying to pump down a group of cells for helium leak detection purposes you'd still have gas in that valve hole. It would be really difficult to get out.

GROSS: Gross, Boeing.

One of the important weak links I think I see is in item 7.4.3 where we say that we will perform the formation as per the manufacturer's schedule. In this section we've directed our attention to what happens after the manufacturer's schedule, and we're talking about the final formation discharge.

Now, prior to the final formation discharge all kinds of black magic and bad things can happen. If we don't do a real good job during the formation, we're naturally asking for trouble. So, his formation schedule, whatever it is, should be very definite, very consistent, should be very repeatable and should be held rigidly. It should not be at all flexible.

GASTON: Gaston, Grumman.

I have a comment on paragraph 7.4.9.5 (c). It says, "Or other metal which is non-corrosive in KOH environment." I think it should be defined a little bit closer, what non-corrosive means. And possibly stainless steel type should be defined.

CARR: Carr of Eagle-Picher.

I'd like to respond to Jerry Halpert's desire. I think, Jerry, that we should have a section in the specification regarding the treatment of rejects, or the treatment of problems and whether it be a MRB, a material review board, or some other method, I think it would be quite applicable here to define the types of defects that we're concerned with and the types of procedure we would follow if we had them.

This could be done by referencing other standard inspection procedures, military standards, or NASA documents or writing out specifically what we want for battery

rms 19

cells.

FORD: Other comments?

HALPERT: I would agree with that and say that there should be some feedback into the process, as Sid has suggested, so that we can find out and at least clear up where the problems were, and the next set would hopefully eliminate that particular problem.

CARR: Right. I agree. Our standard procedures include this. And our silver zinc, nickel cadmium and other battery manufacturers for space programs and other high reliability type units -- you have to assign the cause of the problem, in other words, the analysis of the problem in order to determine the corrective action. And I think it is absolutely required.

MAURER: I have a comment.

I'm a little confused about this question. As I understand the question on leak detection, you are saying that it was impractical to leak check with the electrolyte in the cell because it was difficult to pump it down. My understanding of the reading of this spec is that the leak testing is done in the reverse direction. The cell is filled with helium and you look for helium on the outside, syou you're not pumping down the internals of the cell particularly during the leak check operation.

VOYENTZIE: Voyentzie, General Electric.

rms 20

I think that my comment was associated with the fact that you have a group of cells sitting in a Bell jar which you've just filled with helium and you've got these valve assemblies on them. And pumping the remaining helium out of these valve assemblies could be rather difficult. They'd have to sit there an awfully long time before you cleared the helium hang-up.

MAURER: All right.

FORD: Other comments?

MC CALLUM: McCallum of Battelle.

I have a feeling that when you specify these capacities rigorously, like you have 1.3 times the positive plate and so on that you ought also to specify weight gains back in paragraph 2.2.1.5, you ought to put a weight gain in there.

RUBIN: Rubin, TI.

I take exception to the use of weight gain data because it is misleading and it does not give you an accurate representation of the amount of active material that's in your plate. In normal impregnation procedures, be it the nickel or the cadmium plate, you get black corrosion. And by using weight gain data you're getting misleading values which give you things like 110 percent efficiency of utilization material which obviously is absurd.

rms 21

MCCALLUM: It seems to me that your objective here is reliability and reproducability. And here is a man saying that he's got a critical step in his process that doesn't mean a thing. And I don't see how he can say that and at the same time say he is going to give you a reproducable cell. So, he ought to pin that down in my opinion.

NIETZEL: Nietzel, TI.

Jerry, would you please read our comment to paragraph 2.2.1.5 that we gave you yesterday in which a complete analysis was given of what we do to determine active material loading and what requirements are involved before and after impregnation?

FORD: Would you repeat the paragraph number?

NIETZEL: 2.2.1.5.

FORD: Okay.

Paragraph 2.2.1.5. The stated method of control and measurement is inadequate. The number of impregnation cycles can vary appreciably depending on the method of plaque manufacture as well as impregnation techniques. Therefore, the number of these cycles is of use for a given manufacturer and may not be readily compared to the other processes.

To determine the necessary attribute for controlling the impregnated plate, weight gain data is insufficient and misleading. This measurement in no way

rms 22

corrects for plaque corrosion which varies measurably between positive and negative plates (and process-to-process) and in no way can measure the degree of plaque corrosion which affects the ultimate strength of theplate substrate.

To determine the quantity of active material present in converted and/or foreign plates precise analyses including --

1. Sintered weight per unit area before impregnation.

2. Substrate weight per unit area before impregnation.

3. Sintered weight per unit area after impregnation.

4. Plate weight per unit area after impregnation.

5. Quantity of nickel, cobalt, cadmium, hydroxides and or metals present, must be performed and documented.

Using this type of analysis active material measurements can be made.

HENNIGAN: We had a suggestion for a topic of discussion as to how cadmium exists in the negative plate, and ARt Fleischer has volunteered to say a word or two on that.

FLEISCHER: In listening especially to yesterday's talk about the ratio of cadmium in various forms, everybody

rms 23

has a different name for it, I think we ought to clarify what it is we're really talking about. If you impregnate a sintered plate -- and let's talk only about the negatives now -- you analyze that plate for its cadmium content which is roughly the suggestion that has just been made that we know exactly how much cadmium or how much active nickel is in the plate.

To my knowledge, no one has ever gotten a coefficient of utilization greater than 80 percent out of a sintered plate. In other words, even at the very lowest rate of discharge and the most favorable conditions of charging and of absence of gases within the pores of the plates as a result of charging, you will get somewhere around 80.

Now somebody might have gotten up to 82 percent coefficient of utilization, so the first problem we're faced with is there is 18 percent of the cadmium present in a form which does not respond electrically. In other words, it does not contribute directly to the performance of the cell. It may do it indirectly because there may be reasons why we can't get above this coefficient of utilization. So, the first thing you have to do is we're talking about 80 percent of the cadmium we put in, and this is a capacity that we have determined under a given set of conditions.

rms 24

Now, then, this 80 percent has to be divided into three poritions, as I understand it, the part that is the working cadmium, the part that is the precharged cadmium, and the part that's uncharged, in other words,to prevent hydrogen evolution, because we're talking about sealed cells.

So, we divide our cadmium into four portions and we come out that we should know the total amount of cadmium in the electrode, and this you can only determine by analysis. So, we do have a problem here in defining what we're talking about.

I think that Lou Belove yesterday was talking about the total cadmium in the plates. I may be mistaken. He said he advocates a ratio of 1.8 to 1, so he meant the total amount of cadmium in the plate, but this really isn't a meaningful figure because unless I'm mistaken, this 20 percent of cadmium we don't quite understand its function.

Let's face it. Do we? I don't know of anybody who has ever come up and said the reason that this 20 percent doesn't work is for the following reason and then demonstrated it. Because if he could do that, then he probably could get rid of that 20 percent and be at an advantage overy everybody else, if he knew how to do this.

So, we should define exactly what it is we're talking about with relation to cadmium. And in order to get

rms 25

it going you'll have to do a chemical analysis for cadmium. You will have to know what the cadmium content is.

HENNIGAN: Do we have any more comments on the negative plate?

LANDSMAN: Landsman, MIT.

This weight gain that we're talking about not measuring -- or I think that's what we were talking about -- it still doesn't hurt to include it so that you have a record of it. That's what we've been talking about, we've just got records. We don't know whether we're going to use it or not, but we're going to have some record. And we can compare the future production with the past production.

NIETZEL: The purpose of processes, you do not want to waste your time collecting data that is interpretable. You're here supposedly as a technical individual to try to understand what data you're collecting and how to use it.

If you can't use weight gain, and believe me, you can't, and I'll stand on that one, then let's not waste our time doing that and let's devote our energies to some type of technique where you can collect the data and use it as a function of controlling your processes.

FLEISCHER: No one commented on that remark. To a great extent Nietzel is right, but on the other hand, we

rms 26

all know that every company has a bookkeeping department to keep a lot of records. As far as I'm concerned, they might as well burn them up, they don't mean anything, and yet it's a very expensive part of the business. You keep records about what you pay people and so on, and yet the only thing that really counts is how much profit are you making.

Well, we have the same thing here. We have to do a certain amount of bookkeeping in order to know that our quality and our reliability is going to show up. I don't see how you can avoid this. It's just a part of the job. You're going to have to have records. Now, I don't know what the minimum amount is or where you should stop, but somewhere along your process this is going to fall out. You have to do it in order for yourself to know what you're doing. How do you know that somebody didn't violate the rules, he impregnated for five minutes instead of for ten minutes, or whatever the cycle is. There's always somebody doing something. They set a thermometer on a furnace or a thermocouple on a furnace to control at 1800 instead of 1700 and so on. You have to know what these things are. And you have recording instruments and you have records kept of what is going on.

NIETZEL: I would like to answer it this way: All right, you mentioned certain specifics. Let's look at

rms 27

sintering. All right. A difference of 100 degrees in a sintering temperature. If your process is properly set up and your quality program is set up, you can recognize not 100 degrees shift in your sinter temperature, you can get down to around a 25 degree shift in sinter temperature and recognize the difference in your ultimate parameters.

Now, my personal philosophy is this: Manufacturing is quality control -- period. And when I ask my people to take data that is going to be usable to them, they can sense when they're collecting data that I will not use, our engineering people will not use, our quality assurance people will not use. And they say to themselves why do it? And that's what I say -- why do it?

If you're going to take the time to collect data, let us take data that is useful for the process control.

BELOVE: Belove, Sonotone.

As far as I can understand, one of the purposes of this specification and NASA's deep concern with the nickel cadmium product in all batteries is to be able to obtain traceability, because all of us know we can anticipate some failures, and one of the reasons is to be able to trace back and find out what caused this failure. And if you are to do this, then you must maintain every record, even those about which you may not know the importance at the moment.

Weight gain -- in our experience weight gain does

rms 28

not actually accurately describe the capacity of the cell. Nevertheless, if the weight gain shifts considerably I think the customer may want to know whether this was directly concerned or indirectly concerned with a shift in product performance.

NIETZEL: Nietzel, TI.

If a process outline is set up and then you notice a shift in so-called "weight gain", obviously the process is out of control and the product shouldn't end up going to the customer anyway. So, what does he care about it?

MAURER: We've been looking at the weighing of the negative electrodes before it goes into the cell for the purpose of determining its weight gain. There's another use for this type of data and that is that 10 years from now when JOhn takes a cell apart to see what made it fail or what made it last ten years, he might like to know that figure to see whether the negative plate increased or decreased in those ten years.

(Laughter.)

NIETZEL: Nietzel, TI.

If as a function of your process you end up determining the weight per unit area of your impregnated plate and you know the weight per unit area of your plaque prior to impregnation, you can call that "weight gain," and still use that number. What I'm saying is that weight gain

rms 29

cannot be used as a process control system. That does not mean you don't have the weight gain. You can go back in. You should know what your plaque is weighing before you impregnate it. That's the only way you're going to be able to control your plaque process is to know what's happening in terms of sinter weight per unit area. And you must have some measurement of your final plate prior to analysis if you're going to end up with percent corrosion and a percent cadmium, percent nickel on whatever forms you want to look at it.

So, that data is available. The problem is how do you use it.

FLEISCHER: I'm going to agree with Neitzel for a minute here just to give him small support. There's one part of the weight gain business that we haven't talked about, and that is when you impregnate these plates there's always a surface coating of nickel hydroxide or of cadmium and cadmium hydroxide. And I think this is the principal problem in this thing. If it weren't for that coating that you don't want on there and eventually you scrub off, you could probably relate weight gains to our particular process and the distribution and amount of nickel hydroxide that's formed by corrosion, and the same thing applies in the negative plate, you'll know what the distribution of cadmium is in terms of cadmium hydroxide and cadmium.

rms 30

But there's no way of estimating how much material is on the surface of the plate, and it might be a lot and it might be a little. It depends on a great variety of conditions depending on how often the sodium hydroxide has been used in the polarization and so on and so forth, so I think from that point of view you're absolutely right that sometimes these figures are puzzling. But they do guide you in your control that everything is going along.

Sometimes you get sintered plates which have been sintered and for some reason, maybe related to the type of powder, the properties of the power, the plates don't impregnate properly, and you detect this right away onyour first cycle in manufacturing. You may not have caught this in your control of the plates. So, there's a reason for having weight gain. You can't rule it out.

So, I started out agreeing with you, and now I disagree.

(Laughter.)

NIETZEL: I'll let Ed Rubin take over here.

RUBIN: Rubin, TI.

If you gentlemen listened to the five points that Floyd Ford just read off, you will understand that weight gain can be calculated from the information that we say is necessary to understand the chemistry of the positive and negative plates.

rms 31

I think this discussion has gotten off to the point where we're talking about something that didn't start out, and that is if you're making a measurement, make sure you know what your're measuing and make sure you know how you can use that measurement to control your process.

In the transcript you'll see if you add up items one and two and subtract that from item four, that gives you a weight gain. What we're saying, go deeper than that, understand how much of your plaque you corroded, understand how much nickel hydroxide appears in your negative plate. Then you'll have a better feel for what your plate actually has in terms of chemically active material.

MC CALLUM: McCallum of Battelle.

I'd like to re-emphasize an original point that with all these problems being discussed I can't imagine how you're going to solve them all by saying that if the ratio of the electrical capacities is 1.3, then all these other numbers can be whatever you want just so you have an electrical capacity of 1.3 is not enough.

FLEISCHER: John, who said that?

MC CALLUM: Paragraph 7.4.3 (g) and (d). (g) gives you 1.3 plus or minus .05 and in essence says if you satisfy this you can have any weight gains you'd like to have or any other variable just so you end up with this electrical ratio.

RMS 32

FLEISCHER: The battery men don't get up and talk for themselves on this. Isn't this a point that the committee took in hand that they cannot tell the battery manufacturer how to make their plates. And they have to specify some electrical quantity which they can meet which is reasonable. Now, what you're telling us I think is that we have to tell them how to make the plates.

MC CALLUM: I was suggesting that you give a weight gain on paragraph 2.2.5 -- 2.2.1.5 -- that if you're going to specify an electrical rating and the 7.4.3, you ought to specify some kind of a weight number over in 2.2.1.

FLEISCHER: I think the battery manufacturers ought to answer that question.

NIETZEL: Would you repeat it, please. What was the question?

FLEISCHER: We're talking about -- John, do you want to repeat that paragraph? I've lost it here.

MC CALLUM: The question I guess is whether you can specify in paragraph 2.2.1.5 a weight gain number that will give you the electrical requirement in paragraph 7.4.3 (g).

NIETZEL: If we really take a look at this now, I think it's starting to be self-evident that they're not compatible. The paragraph on weight gain merely states

rms 33

that it is to be recorded and supplied. It does not say it is to be interpreted. So they are incompatible. And that's the point that we've been trying to make and that is that 2.2.1.5 does not really give you the information you're looking for. And we offered an alternate to that. All right?

MC CALLUM: As I understood your alternate, you were giving an alternative set of data to be recorded, and it still can be any number that any manufacturer wants to record, just so he records it, and the question is whether you can give a number in paragraph 2.2.1.5 which will lead to the requirement in 7.4.3 (g).

REED: Reed from Battelle.

If I could comment on that, I think the answer to the previous question is probably no, you cannot specify a weight gain that will give you this ratio because we've just learned from various manufacturers that the amount of active material which you must impregnate to get a certain electrical capacity is a function of the process which is used.

HALPERT: I would like to ask the question then: Since I was responsible for writing up this area, how would one then make a specification or put a specification here that would give you the requirement in section seven. Does each manufacturer have a weight gain which is related to the weight gain corrosion content which is related to capacity? And if they do, are they willing to supply it for each case?

RUBIN: Rubin, TI.

First of all, I don't necessarily accept 1.3 as an aboslute value, but if a user came to TI and said that he wanted a negative to positive ratio as specified in section (q) here of 1.3, then we have the chemistry available to manufacture specifically that type of ratio.

Again, in talking about this ratio, not all applications should have a 1.3 plus or minus .05, but if that is what is desired by the user, that can be made using and implementing the analytical data that's available. And that will be presented to the user in specification form. That's what we do now.

FORD: I'd like to clarify a point on that particular paragraph that's so deep in discussion. If you read the paragraph it implied but it is not explicitly stated that this is to demonstrate that that capacity is there. The tolerance is misleading. It should be a minimum of 1.3. Anything above that is not to be rejected.

RUBIN: There are very few things that I reject out of hand, but one of them is an open-ended tolerance. I would recommend that if a user understands the nickel-cad process sufficiently to specify what he considers for

rms 35

his application, a reasonable ratio, then he should so specify it to the manufacturer to indicate what tolerance he can hold out to. Now, if the user feels that's reasonable, then he can buy it. If not, then it has to be discussed. But that ratio can be closely controlled even to the misinterpreted tolerance that I put on it. I object to open-ended tolerances.

FORD: If I understand what you're saying, you're saying that the specification should include a ratio number with a minimum and a maximum?

RUBIN: No. This specification should allow a manufacturer to design the cell for an application. I'm a firm believer that the negative to positive ratio is a design parameter, and it cannot be used universally for all applications. Some applications -- 1.3 is insufficient, or you'd have to go to two to one. But that is a design parameter.

For most space applications that I've seen this type of ratio is reasonable, but I would say that when a user buys a battery or cell and he wants a certain ratio that it should actually have a tolerance on it and not be open-ended.

SULKES: Sulkes, U.S. Army Electronics Command.

One problem where you're specifying 1.3 is that once the plate stack gets further processing that ratio

rms 36

can be completely lost in that there may be an excess of cadmium hydroxide available, and the actual ratio as you get further downstream may end up one-one, one to 1.2 or anything.

At the place you've specified it, it doesn't really control the final cell. I think it has basically no meaning, because by formation charging and by how far you deep discharge, you can control it anyway you want.

I mean if you just want to have them come up with this number, it really doesn't give you your final cell to do what you want.

FORD: Are you referring to precharge?

SULKES: Yes, in other words, you've precharged. You've run this test, but after that there's a lot more processing that goes into it. And the state of charge or this balance can change all over the lot.

FORD: Well, I might comment this time. It is my personal feeling that at this point this particular paragraph will be changed to read that the negatives will be discharged completely during this period.

Are there other comments?

GROSS: Gross, Boeing.

I would like to hear comments from people on how to resolve the question of definition of cadmium capacity that Art Fleischer discussed. He presented the problem. It

rms 37

has to be solved. Are we going to talk about theoretical capacity, or what are we going to do? How are we going to solve the problem of definitions.

FORD: I think there's another section -- I'm not sure which chapter it is -- where it's called a ratio test. And we'll probably be getting into that a little deeper. I think that will be discussed before the day is over.

GASTON: Gaston, Grumman.

I have two specific comments. One of them is on paragraph 7.4.9.5 (d). It says, "Place jackets on cells." I think jackets should be defined a little bit closer. They shall be parallel and certainly they shall not warp after restraining(?). So possibly some additions could be made on this specific item on jackets.

The next comment I have is onparagraph 7.4.10.1(a). It says, "Backfill with helium." Possibly a certification of helium would be desirable or an analysis be conducted on the helium.

FORD: You mean for impurities?

GASTON: For impurities, yes.

FORD: We are going for a coffee break in a few minutes, so I'd like to contain the discussion up until that time, because after the coffee break I think we'll probably go into another area.

CARR: Carr of Eagle-Picher.

rms 38

I'd like to just discuss one other thing we've hit on a few times and that's the carbonate problem. I might ask for some support from the gentleman from Battelle and the gentleman from the Canadian Defense establishment.

It seems to me that we're talking about two different types of carbonate, or let's say we're worried about two different types of carbonate. One, the carbonate that we're introducing into the cell as a result of contamination from the atmosphere of either plates or electrolyte. And then there is the problem of the separator resulting in carbonate. Now, it seems to me that the orders of magnitude are somewhat different. And I'm wondering if maybe the controls are more unrealistic than they should be during the manufacture, such as the plus or minus 3 minutes type of thing, as compared to what actually happens when the battery is used.

FORD: Would anyone care to comment on that? Or question it?

REED: Reed from Battelle.

I'll try to comment on that just a little bit, if I can. I don't know whether I'll answer the question satisfactorily. But it appears from evidence more in the literature and also some that we have that carbonate in the cell in low quantities is not particularly detrimental to cell performance.

rms 39

Now, what you define as low, obviously is going to depend on your operating regime. However, it appears in general that a concentration of carbonate on the order of 100 grams per liter, or about 25 percent of your total KOH converted to carbonate is definitely detrimental to cell performance.

Now, then, we're talking first of all the total carbonate in the electrolyte back in a paragraph which I've forgotten. The orginal specification recommended .01 grams per liter which I feel is way too low.

Dr. King mentioned a figure yesterday I believe of 4 percent, which in 30 percent KOH is more like 50 grams per liter. Now, certainly you don't want to start out with your KOH at that concentration of carbonate. However, it is possible without great difficulty to make KOH with a couple grams or less of carbonate per liter.

Now then, of course, it's going to pick up from various portions in the manufacturing process and from the separator, so we want to start out with a low concentration and assume that it will increase some.

The idea, of course, is to have enough process control that eventually the concentration of carbonate will still be below the somewhat critical concentration for operation of the cell.

FLEISCHER: My partner in sin, Pete Voyentzie, and

rms 40

I worked on a project with Inland Testing for Wright-Patterson in which four different manufacturers, as I remember, of nickel cadmium batteries were cycled on various regimes at various temperatures, and in setting up the program we allowed for taking one sample right at the start of each group put on test. These cells were sent back to the manufacturers for their analysis.

And one of the surprising things that came out in two of the manufacturer's cells there was a carbonate content of about 130 grams per liter right at the start. So, the question was how did this come about. And it very soon came out that the plates that were used in manufacturing these cells had been set aside after their formation and allowed to stand around for two or three months, or so it was reported. So, they were thoroughly carbonated.

So, the principal source of contamination here was due to negiligence in storage, taking the proper care. Now, there has to be some way in which the user can be guaranteed that this doesn't happen, because it was sort of ridiculous to run that very expensive test which had an aim in trying to find out how to run a failure analysis and how to run a cycle life test to determine what the probable life of a battery was.

And here two of the four manufacturers sent cells which had carbonate contents which are just not tolerable.

rms 41

So that the tests actually for the original purpose had no meaning. And well now what does the user do about this? Should he have gone back to the manufacturer and said look these cells are not acceptable, give us back the money. What about the cost of the testing?

These are very serious things,and I don't see any way of settling this problem unless we put it into a specification.

KING: King, Ottawa.

I'd like to say just one or two words on the carbonate. First of all, I'd like to agree with Dr. Fleischer. We find that most of our trouble emanates from the plate. And if we find large amounts, we remove it from the cell, get it down to the proper percentage.

Now, in mentioning yesterday four percent, this was a cell content and not the electrolyte used. In the electrolyte it's usually less one percent, and you will find a pick up in your cell, up to below 4 percent. And this is coming mainly from the plate and not from our separator.

FORD: Dr. King, I would like to ask you a question along those lines. Do you normally pull sample cells from production and do some type of test to determine the carbonate content on flight type cells?

KING: I would say that's 100 percent.

RUBIN: Rubin, TI.

rms 42

In referring to the carbonate problem, work done at TI indicates that you can actually manufacture carbonate within your cell after it's sealed. And this occurs because of a chloride ion that's present in some separators. Now, there is a reaction that occurs between a positive plate and a chloride ion that forms a hyper-chloride compound which in turn reacts with a secondary amine group on the Pellon separator and undergoes what is known as a HOffman degradation, and this tends to split off certain chains within the separator and the decomposition product is CO_2, which of course in the cell environment is converted to carbonate.

So, even under the most scrupulously controlled conditions you can under certain circumstances -- we have shown this in laboratory studies -- produce carbonate within a sealed cell.

FLEISCHER: Everybody expresses the percent carbonate in the electrolyte differently, and this is a small point. I think King is talking about the percent of potassium carbonate in a solution. I like to talk about the percent of carbonate on the equivalent basis, because then all you have to do is to divide the results of the titration. You actually have to do no calculations whatever. You just calculate -- your readings, you divide the carbonate part by the total titration. There's a little equation you set up. It's very simple. You can do it in your head. And that gives you the percent of carbonate. So, you have no further worry about anything. You don't have to know the equivalent rates. You don't have to sit down. And anybody can do it. So, I think we haven't done it in here and it would be a good idea if we all agreed that the way to express the percent carbonate is by equivalents. That's the answer you get in the titration.

RICHARDSON: What value?

FLEISCHER: You have a total alkalinity of the cell which is what you titrate, the KOH plus k2CO3, that's your total titration. That is the number of equivalents. So, you also have the titration for carbonate. So, you divide the two figures, and that's the percent of carbonate by the equivalents.

RICHARDSON: What is the acceptable value of KOH?

FLEISCHER: Oh, you mean of carbonate?

RICHARDSON: Yes.

FLEISCHER: Oh, it's somewhere around three or four percent. I've forgotten the relationship. It is small. If you can keep it there, then you have no worries. It doesn't matter how you express it. But it's when it goes up that you have to worry.

KING: I would just like to mention to Dr. Fleischer that I did use the term two equivalent percents yesterday.

We use that in the lab but for outside we use weights.

MAURER: I would like to comment on the utilization of positive to active material. I think Ed commented that the utilizations of greater than 100 percent of the theoretical active material on the plate were ridiculous because you may not have calculated the weight of active material on the plate properly.

I agree that that's one source of error. The other source of error, however, is that you haven't used the proper theory. Most people use the one electron transfer and there is a possibility of other things happening.

RUBIN: I agree. And even if you use more reasonable values of a valence change, using the weight gain data will still give you those misleading results. But even using values that are arrived at like 1.2 electrons, you can arrive at those values by looking at the valence of the nickel, by analytical means, even using that correction factor, you'll still, if you use weight gain data, will get values of greater than 100 percent.

NIETZEL: Nietzel, TI.

One comment I was going to have here on this three-minute time period. My personal concern on that is not so much the problem of carbonate pick-up but the problem of losing your free cadmium adjustment because of oxygen, and therefore indiscriminately leaving these things open,

rms 45

you know, you'll end up losing that whole thing.

RICHARDSON: Richardson, Marshall.

On that 523, it's still not clear in my mind what is the acceptable weight carbonate concentration. The spec shows .01 grams per liter. Is this a realistic value that we ought to set, or is two or three grams per liter more realistic or what?

FORD: I will answer your question in a minute. Dr. McCallum has a comment. I do have an answer to your question.

NIETZEL: In terms of the .01 grams per liter, our comment on that was to convert that. We thought we should see their 01 moles per liter. My personal recommendation would be 10th molar. And I think that can be controlled very easily. Inert gas flowing over after you mix your material. Put a blanket and then you won't have any problems.

MC CALLUM: McCallum, Battelle.

I was wondering if our friend from TI could comment on his remark that he can control the electrical ratio, 1.3, very closely and get the customer any number he wants, but that the weight gains are not the way he does it. And I wondered if he could tell me how he does that, if it isn't by weight gain.

NIETZEL: For a small investment you can come up

rms 46

and see us, and we will be glad to tell you.

(Laughter.)

There are people on the panel who are aware of how we do that, and I am confident that they understand our systems. It is not an Ouija board. It's supposed to be science. And I say we can do it. People on the panel board know we can do it. And I didn't mean that as a sales pitch, but it can be done.

And I have a feeling that there's a few other people around here that are catching on pretty fast on how to do it.

FORD: Are there any other comments before we take a coffee break.

RICHARDSON: Floyd, you're going to answer my question.

(Laughter.)

RICHARDSON: I'm asking you. That's his opinion.

FORD: I don't know what the answer is. No, I'm not going to answer it.

RICHARDSON: Okay.

(Laughter.)

(Coffee break.)

HENNIGAN: I would like to call the meeting to order for the second part of the morning session.

One thing I would like to repeat is a statement

rms 47

that I read yesterday morning, so we don't get too far afield. The statement read as such: It was not the intent of NASA and industry personnel to attach the interim spec to purchase requests and require the battery industry to conform overnight. This would have been impossible. The spec was given wide distribution so that users could have a document from which they could take information to be incorporated in their own specifications where they saw a need.

It has been noted that in several instances this has been the case. It is my feeling that a uniform specification would be useful in approaching standardization and obtaining a basis for bidding on purchase requests. We kind of felt that maybe we should repeat that statement. And this is a model specification, and it has to be revised so that it will be generally acceptable to manufacturers and users.

There is one other point that our chairman brought up. The spec as written is for prismatic cells, as stated in paragraph 1.1. And it does not cover cylindrical cells. At the time we sat down to write this spec we felt that the wide use of prismatic cells at this time would not eliminate the cylindrical cells, but that we feel would take a separate specification.

We have also noticed that people seem to be a little bit worried about the extensive testing. Probably what we have to do is have two types of testing -- qualification of materials and components as they are going through a process. Now, for instance, if a batch test is run, we would feel that you wouldn't have to run this test on the batch every time you put through cells, if you felt this material was properly stored and did not change with time.

Now, some things I guess do change with time, like plates if they're stored, so some things would have to be run again.

One point that's well taken is the statistical sampling for testing per the mil spec, which a certain sample size is taken, if they pass, the lot passes. If they don't pass, you have to take a larger and larger sample. This is a well accepted technique.

We also appreciate the material review board approach. This seemsto be something that we feel -- the chairman felt was well taken and could be put into effect.

There seems to be a lot of worry about the cost of implementing this spec entirely or in part. And we do have some numbers that are practical numbers because they come out of bids and purchases.

I think Floyd Ford has an approximate number that showed the increase when the spec was taken entirely. Is that right, Floyd?

FORD: Yes. I will pass it on to Steve Gaston, where the spec was taken partly and included in a purchase for the recent OAO battery. Steve has an estimate of what the results were.

GASTON: I believe yesterday it was mentioned that approximately 60 percent of this new specification has been incorporated in the recent bid on the OAO battery cells. And a rough estimate is that the cost ratio is between two and three to one. That was before. Now it is between 200 and 300 percent of the original cost.

HALPERT: That is without section 2, right?

GASTON: Yes.

FORD: I would like to emphasize that is not referrring to this particular spec that we're talking about here in the meeting.

HENNIGAN: The implementation is about 60 percent of it in a Grumman spec.

GASTON: Right.

HENNIGAN: Did you have any comments, Jerry?

HALPERT: Yes, I would like to, if I may, make some comments about the nickel powder which we have not even discussed in here. I guess it's an error of omission, but there are certain properties of the nickel powder itself, which we certainly want to consider -- shrinkage being one and possibly wetting another. And I'm sure there are some other tests which you may want to recommend and the

rms 50

audience may want to make some recommendations on that.

As a second item, I wonder whether Mr. Mearns of International Nickel who is visiting with us today may have comments. We are in the midst of a nickel strike since July, and it may be of some interest on the status of that strike and the availability of materials, since we're talking about nickel cadmium cells that utilize quite a bit of nickel. And I wonder whether we're going to be affected at all in the future.

MEARNS: As you know, we are on strike. Inco and union negotiators continue to talk at the bargaining table as new efforts are made to end the Ontario nickel strike. On Monday, October 27, Inco made a wage increase offer of about $1.33 an hour. Guessing in some circles is that the strike may end in November. That is the latest I know on the strike.

STEMMLE: What are the chances of getting nickel? Is there a good stockpile, or is there a shortage in, say, nickel sheet or nickel powder?

MEARNS: Everyone asks that question on a time-table. When the strike ends it will be sometime before nickel is available. Some are guessing it will take six weeks or so before nickel powder is available, and no set timetable is available.

rms 51

HALPERT: Another question if I may. I understand there is some contemplation of building a facility in Sudbury in Canada to provide these powders rather than getting them from way off. What is the status of that? Is there going to be a facility there?

MEARNS: I am not familiar with the plant or the schedule. We do have a new Inco pressure carbonyl (IPC) process, which is a development in chemical metallurgy for treating sulfide ores and intermediate concentrates which is scheduled for completion in the latter part of 1972. The plant will have an annual capacity of 100 million pounds in the form of nickel pellets and 25 million pounds in the form of nickel powders.

The IPC complex will also produce copper, cobalt and sulfur, and will be located at Copper Cliff in Canada.

MC CARTER: McCarter, Eagle-Picher.

If the strike is settled rapidly, how long will it be before we get back to where we don't have to have DO and DX to get supplies?

MEARNS: That's a question everyone asks us. And I don't think any of us know the answer. Some people say it will be four weeks and some people say it will be six. We don't really know.

GROSS: Gross, Boeing.

I would like to see the specification expanded to

rms 52

include not only the unmanned satellite applications but to give a little thought to the special problems of manned spacecraft. We know that safety will be an important factor. And I don't have any inputs that I could read off right now, but I would certainly like to see the specification expanded in that area.

HENNIGAN: Any other comments before we get on to the separator portion?

(No response.)

We will cover the separator portion of the specification which is paragraph 3.0.

On the first paragraph 3.1 which is concerned with the separator weight per unit area, we have two comments there. The conditions should be 21.1° C plus or minus 1.1 and 65 plus or minus 2 percent relative humidity. This is per federal test standard number 191, which I understand is a test spec for textile materials.

The target spec of 60 plus or minus 1 gram per meter squared is not within the capability of the commercial facility. Our current specification is 60 plus or minus 8 grams per meter squared. They feel they could hold 60 plus or minus 6 grams per meter squared.

Are there any more comments on 3.1?

(No response.)

HENNIGAN: On 3.2 the absorption, dimensional change,

rms 53

electrolyte retention and porosity.

The comment we have is that measurements should be made using an Ames gage or equivalent. Since a wet sample will be compared to a dry sample, weighing the dry sample to a tenth of a milligram seems to be unwarranted.

Jerry?

HALPERT: I would like to make a comment on that. On thickness evidently there are a number of different gages one can use to measure thickness, and everyone gives you a different answer. I don't really know whether we know what thickness is in terms of the separator in the cells, since when we put it together we squeeze it down to some other value other than what we started with.

I just make this comment that I think some standard for thickness which may be more meaningful -- it should be more meaningful than any of these particular Ames gages -- might be in order.

Maybe somebody has a comment about thickness measurement.

FLEISCHER: I took this matter up in one of my reports to Fort Monmouth. I can't remember the number. But I went into it very extensively. And roughly what we did was to use two quarter inch plates, steel plates that we had polished very carefully, and we put the separator between these plates.

rms 54

As I remember, the two plates together were .4 or .5 inches thick. And this was just the right amount of pressure, and it coincided with the references that were given there for achieving a meaningful thickness for woven materials and non-woven materials. But it is in that report. I went through it, and I've forgotten what the number is. But I'll try to find it and I'll get it for you.

HENNIGAN: There was another comment here on 3.2, the type of gage we're using, they suggested a Cady Gage Model DW-1 and the Ames gage.

Also on 3.2 they suggested that their method of measuing electrolyte absorption using a Kubelkaglas be instituted for weighing samples before and after immersion in electrolyte. I don't know if you understand what this is. It's a beaker that has a long tube on it that is calibrated like a buret. And the electrolyte is put in the tube, and the sample is put in the beaker. And you tip it, let it soak for a certain length of time, and then you tip it back. And then you measure the amount of electrolyte for the second time and you find out how much was absorbed by the difference. It was kind of an invention by the company I think.

3.3 is separator resistance.

The comment was this test currently not performed at the company. Sufficient data would have to be accumulated to determine the target specification.

rms 55

Are there any comments on the method they use for resistance measurements?

(No response.)

And 3.4, separator wetability. This test unacceptable from a separator manufacturer standpoint. Must have in-house wetability test while separator is being manufactured.

I don't quite understand that comment.

3.5 Tensile strength. They have suggested Federal Test Method 5102 of Federal Test No. 191 be used instead of the reference test.

This again, this test 191, applies to textile materials. The test presently being used is a jawbone(?) is cut and put into a regular tensile machine and pulled. I couldn't find this spec 191. It is on order.

3.6, Extractable Organic Content.

Does anyone have any comments on that paragraph? Does anybody have any comments on the solids(?) that are being used?

NIETZEL: We have a comment here that extraction using methanol will remove some inorganics such as zinc chloride which would be which would be counted as an organic constituent using this method and should be subtracted out. You would have to do a little talking I think on some of the analytical approaches here. We have to do something

rms 56

analytical. And I think we're going to have to get down to some nitty gritty on just how to attack this.

On methanol alone we'll have to now describe the purity and water content of the methanol and just how dry it is, so maybe this will startto develop as the morning progresses. I hope so.

HENNIGAN: Thank you.

3.7, Inorganic Content.

One of the comments is the target spec of 0.25 percent is too low. Typical data is currently one percent. They suggest a target of .75 percent.

There is another comment. Ignition of the residue will volatilize certain inorganics, for instance zinc oxide.

Are there any comments on 3.7. Do you remember the numbers we are getting on that? Steve? They're higher than one percent I believe.

GASTON: Gaston from Grumman.

On the percent inorganic residue, I have numbers for Pellon ranging from .111 to .170.

HENNIGAN: So, there wasn't any spec.

3.8, Discoloration in Electrolyte.

Does anyone have any comment onthat paragraph?

(No response.)

The reference there is a Munsell color standard

rms 57

which I've used before, and it seems to be quite a good color standard.

GASTON: I would like to correct that statement. The percent ash was from .44 to .76, so it is higher than the specification had specified. I had the water extract before. So, it is somewhat higher than the target specification.

NIETZEL: What was the ignition temperature there, please.

GASTON: I'm trying to find it.

HENNIGAN: This is probably a good point, and we should specify a temperature.

GASTON: That's a good point. I don't see it here at the moment. It is not stated in this report. I will have to find out.

HENNIGAN: Thank you.

Paragraph 3.9, Thickness Variation.

Jerry, go ahead.

HALPERT: On the thickness variation I was informed by one of the separator people that were here earlier this morning that the beginning and the end of every roll is quite a different than what would be expected to be a continuous run and that it is recommended that we at least go back in the run on the order of five to ten yards before taking the first sample and before the end cut off

rms 58

the last five or ten yards before taking the last one.

FLEISCHER: Does that mean you should throw the first and last five yards?

HALPERT: Yes. That's what he said. His comment was that the calender which may or may not be used -- if it is used, the calender is released to some extent at the beginning of the run and then is set while the run is started for set up and is removed toward the end of the run when it is being completed, so that the thickness at the beginnin and ends might be significantly different than what might be the thickness in the middle.

FLEISCHER: WEll, I think he shouldn't deliver the first five yards.

NIETZEL: Jerry, we have observed that ourselves. And I think part of the problems on incoming inspection is to make sure that the sample being inspected does represent the product that you're going to use.

HENNIGAN: There is a comment here. In order to take thickness measurements on samples from the beginning, middle and end of a slitted roll, this must be an in-process test.

What he meant by this was the battery manufacturer should do it while he is processing the separator. Oscar?

NIETZEL: If that is the case, will he accept our rejection then?

rms 59

HENNIGAN: You will have to ask him.

NIETZEL: That's a problem.

HENNIGAN: Yes, it is. Was there another comment?

HERZLICH: I was going to make the same comment.

HENNIGAN: All right. Thank you.

Materials Used in Cell Formation, paragraph 3.10.

There is a comment here. We do not believe that the requirements for the formation separator of paragraph 3.2, which refers to the absorption, retention and porosity, 3.4.2 which refers to wetability and 3.5 which refers to tensile strength, are technically justified. This separator is not used in the finished cell. The tests outlined in 3.6 and 3.7 may be of interest since they do determine if any contaminants are introduced in the formation.

Are there any further comments on that paragraph?

Oscar.

NIETZEL: I'd like to make a comment on the comment, please. One way to get into trouble is to have available the potential for trouble. And that's what this comment allows. It is very difficult to have control in your processing and in your material handling, if you're going to allow within an area a certain batch that has one spec and another batch that has another spec. Murphy's law will strike. It has to strike. And it states that if it can happen, it will happen. And that's a fact. So, I do not

rms 60

like that comment. You just have a certain grade in house and that's what you should be using.

HENNIGAN: Thank you.

Any more comments on 3.10?

(No response.)

3.11, Separator Material Used in Production Cells.

There was one comment that this paragraph is totally impractical on a separator manufactured on commercial equipment.

Well, I asked them about that and they said well this was up to the battery manufacturers to check it.

CARP: In direct reference to that comment I would like to see something in the specification to the effect that where the inspection is done there are three distinct areas here. We have the manufacturing inspection, maybe actually four areas, manufacturing inspection, their acceptance of the material, then our receiving inspection of the material and then again any tests that are done on individual pieces of separator as opposed to the roll. We buy the material as a roll. And then we cut it to size. Either in pieces or in a strip. And I would like to see some breakdown of how we would go about inspecting.

HALPERT: Good point.

RICHARDSON: On 3.11 here, I would think, Pete -- or Earl rather -- that you'd want at receiving when you buy

rms 61

the material from Pellon or wherever it is, that you'd probably want to run your 100 percent possibly on the whole roll. But then if you put it in storage and it sits around a while, and then you to ahead and cut the Pellon up to a given size to fit a given size plate, I think you'd want to run another visual check to see if you hadn't picked up any extraneous material due to the handling and cutting of the Pellon in the processing of it. So, I think you'd want to run another visual of some sort by the inspection or by the operator who is going to put the separator on the plates.

CARR: I agree completely, John. There is another problem and that is that we have many more than one type of separator in the house, and again we're talking about Murphy's law.

FLEISCHER: That reminded me of what happened at East Hampton on one occasion with woven nylon cloth. We received it in rolls and sent it out to be slit, and our cells foamed and foamed and we couldn't make cells. So when we analyzed the problem and went through the whole thing we discovered that the ________ mill used an anti-static agent on their nylon bobbins over which the material rolled. And they introduced the anti-static agent which was also a good foaming agent. So, you can have things happen on the way to cutting up nylon depending on -- or your separator --

rms 62

depending on who does it and what care is taken.

HENNIGAN: We do have in our data sheet, it goes along with the separator data sheet, not to use an anti-static agent. We've heard about that whole problem.

Bill?

BILLERBECK: I think probably one omission is a specification on storage of the material prior to its use here. The gentleman from Marshall brought out that there is a real possibility for contamination during the storage period.

STEINHAUER: Steinhauer, Hughes.

In paragraph 3.0 I wonder if we shouldn't use the "filtered", non-woven could apply to a membrane type of material.

HALPERT: We have a lot of tests here. One of the tests that is not included is air permeability, and I understand that our Canadian friends have used this as a criterion and I wonder if Dr. King might say a couple of words about the/air permeability of separators as a test for control.

KING: I think the best way to describe our permeability requirements is to read from the specification S-615-P-17 which was issued by Goddard SpaceFlight Center.

It states, "The separator material shall be a non-woven polypropylene material free from flaws or other imperfections. The air permeability of the installed separator

Page 250 Missing in Original Document

rms 64

subject of particles in the separator was discussed, and there has been some feedback that at one time or another the separator has been found on incoming inspection with metallic particles in the separator.

This type of think getting into a cell could be detrimental. I might suggest some type of test along the lines of screening for metallic particles that are not necessarily visible to the eye when you look at the separator on a visual test. We might look towards the people making capacitors, because they have also had problems, dielectrics coming in with metallic particles that would lead to high failure rates in capacitors.

I think this is an area we should be concerned with.

HENNIGAN: Are there any more comments on the separator?

(No response.)

I'll turn the meeting over to you, Jerry.

Oh, I'm sorry. We've got a couple.

CARR: Just in reference to 3.11. In addition to particles in the separator, it is also possible to have areas that have holes in them, so the 100 percent inspection of separator material appears to be required, 100 percent inspection at the assembly separation level where you do the separating of the cell.

NIETZEL: We are now going to leave the spec. We

rms 65

made a comment earlier here on this Hoffman degradation reaction. I didn't hear anything off the floor about it. Maybe I don't believe it, but one of the problems we're concerned with here is chloride ion concentration, and I don't see that here on the spec. I wonder if anyone else is concerned about it. And if so, how would they like to set up analytical procedures to determine what it is.

HENNIGAN: Well, in 3.7 we're supposed to determine the amount of chloride.

NEITZEL: What about spec limits?

HENNIGAN: We don't know what it should be, but some of the numbers are running rather high.

NIETZEL: Yes, they are.

HENNIGAN: Point nine percent.

NIETZEL: Nine thousand parts per million, right.

CARR: One of our problems it seems that we don't know all the results of the different impurities, but it appears that this one is a bad, so I think some real concern ought to be given here.

NIETZEL: I think another problem is if chloride ion exists you know there has to be usually some metallic constituent with it. It doesn't appear to be sodium ion. I think it's zinc, because it's an activating agent. And that's why some of our concern in here for solubility of zinc, the zinc chloride, in methanol also the ability to

rms 66

drive off the zinc when we're looking at firing for an oxide residue. So we'd just like to throw this out for comments please.

HENNNIGAN: Does anybody have any comment from the zinc chloride content.

STEMMLE: Stemmle, Goddard.

In our labs there is some work going on with the X-ray machine for using X-ray fluorescence I believe, determining the concentration of chloride and zinc, and apparently both of these are present in about the same amount on the Pellon. The X-ray is one way of doing it.

HENNIGAN: Thank you for your comments. And I'll turn the meeting over to Jerry Halpert.

HALPERT: The next section dealing with Section 8, Production Cell Acceptance Tests, will be chaired by Will Scott.

SCOTT: Section 8 is concerning acceptance tests on completed cells. The first submitted comments that I have are related to Section 8.1.2. I don't have any before that. Are there others. I don't know whether I have a complete list or not.

Okay, the first comment is still regarding 8.1.2. But I see that it really relates to the entire set of requirements.

If there are no other -- there isn't really much

rms 67

to talk about before that section anyhow. So, the comment is temperature tolerance difficult to maintain. Discharge to 1.0 volts difficult to control. Seventeen-hour charge is costly. Shock and vibration not necessary. X-ray of minimal value. This comment is from Thierfelder. Would you like to say anything further.

THIERFELDER: I think the temperature limits were plus or minus 2°F. Yes. Well, it has been my experience that this is beyond the capability to maintain in a regular test facility.

SCOTT: Excuse me, are you referring to the numbers in section 8.4 and 8.5.

THIERFELDER: That's right.

SCOTT: And 8.6. Those three, because I see they run all the way -- plus or minus 2° runs all the way through here.

THIERFELDER: And on many programs we start out with numbers like this, and before the program is very far downstream we're saying like plus or minus 3°C which is then quite a bit beyond this.

The other comment about the discharging of cells down to 1.00 volts, the same thing there, we have tried this and found that when the cells get below say 1.1 or even 1.15, it may take 20 or 30 seconds before they go down to zero volts and into reverse. So, we have limited testing down to 115 to prevent this, and we've even had very sophisticated equipment. We automatically scan through the cells and scan through anywhere from 50 to 100 cells in less than a minute. And you scan through once, and the cells are up above 115, and on the next scan a minute later the cells have reversed. And we've had this happen on several occasions, so we do not discharge the cells below the 115, minimum voltage.

What were some of the other things?

SCOTT: Seventeen-hour charge.

THIERFELDER: WEll, this is just a matter of time. I mean if you can charge the cells in eight hours, why take 17 hours. And I think I made a comment about vibration and shock. Well, on a hundred percent basis we have never done shock, and we did vibration for some years. And on the prismatic cells, we looked back over the data and found we had no failures in vibration in over -- I don't know what the number was, but it was many, many hindreds of cells. And then we stopped vibrating on the production basis.

On the X-ray, we also on the earlier Nimbus programs, Relay programs, we X-rayed all the cells in three different directions looking for everything from weld leaks to what we could find. And I personally spent many, many hours examining X-rays and finally the only thing we did find them useful for was on the spirally-wound cells, the

rms 69

round cells, and it did show up telescoping of the spiral. Other than that we found it really of no use, and we stopped X-raying because we were spending time and effort and not coming up with any results. And of course in some cases where cells did fail, the question came up -- go back to the X-ray and find out what the X-ray will show. And in no case did it actually give any information that was useful in the failure analysis.

RICHARDSON: Richardson, Marshall.

I've got several things here, one is I notice you have this organized in 8, 2, 3, 4, 5, like examination, your leak test, your capacity. Is this to suggest a suggested acceptance test sequence, or did this just happen the way that when the sections were entered in here, it happens that's the way they fell in place, or is there any rationale for putting them in that order you have them in?

SCOTT: I might comment on that. I don't believe that the order in which they appear is necessarily intended to indicate the best order or any specific order. It may. However, I do believe there is probably a preferable order. And possibly that order should be indicated in some separate paragraph ultimately.

RICHARDSON: Very good. Next on the high temperature capacity and the low temperature capacity tests you spell out, for example, for high you show maintain at 90 plus or minus 2. Well, see, our requirements for our ni-cad cells, the high temperature may not be 90°. It might be 80 or something like this. And likewise on the low temperature side, we may have a different low temperature requirement for the operation of our cells, so therefore maybe this ought to be left open to the user, instead of spelling out a given temperature which may fit your requirements in this case.

In addition, in the vibration section I don't think it is a good idea to spell out given vibration requirements, because the ni-cad cells we're going to use in ATM and Airlock module, this vibration criteria would not apply to the acceptance levels that we would use in vibration of the cells or the batteries themselves, so here again a suggestion would be that vibration criteria ought to be open to the using agency which you could spell out for a given use. Because in addition a four-ampere-hour cell would have different characteristics than a 33-ampere-hour cell under vibration. And some cells maybe due to internal structural differences here again would react different under sinusoidal and random.

BILLERBECK: Billerbeck, Comsat.

I'd like to comment on several of these. I think the intention here was to show some typical environments

rms 71

rather than the detailed one, since it is a model specification, why indeed those things certainly open to the user to specify.

On the temperatures there was some feeling in the committee that there is a need to have some temperature and charge rate limits that are as universal as possible so that one can relate data taken from one program to data taken from another. And that's a real problem because you really have some conflicting requirements there. You would like to have the charge and discharge measurements so that you could relate between programs, but at the same time you want to know specifically what's it going to do in my program. I think that is something to be resolved.

FORD: Ford, NASA Goddard.

I don't think this is to be implied that these are all the tests that will be conducted on these cells. The implication here, as Billerbeck has indicated, is a set of standard conditions that would be applicable to all cells, and consequently to all manufacturers.

The point I want to make is this is not written to accommodate any specific program or any specific project?

RICHARDSON: But generally when you run acceptance testing it's for a given use in your program. If you have a high temperature requirement of 100°F, you want to test the

rms 72

cell at 100. You don't want to test it at 90, because the application is not at 90. And likewise if you're going to operate it at -15, here again, minus 15 below zero or something like this, I don't think you want to operate -- you're talking about 32 or something that you have in the spec.

FORD: I agree with what you're saying, but I think what is implied here is that before you ever receive your cell to go through your specification, each manufacturer conduct his own tests, prior to running your tests. And it would be idealistic that they would be a comparison of this data, not only within a manufacturer from year to year but across the board throughout all cells you may possibly use from other sources.

RICHARDSON: What are you trying to say then that we run two acceptance tests, one at 90 to get a baseline for data and then run another high temperature.

FORD: That is currently being done in most cases today.

BILLERBECK: I think it actually turns out that in many cases these conditions are acceptable, but in some cases there may be in addition some special requirements for a particular program, high rate discharge, different temperature limits and so on.

So, one approach is to do these as a standard

rms 73

set of tests and then add any special requirements.

SULKES: Sulkes, U.S. Army Electronics Command.

In your temperature limits you call out the cell case temperature shall be controlled. And this would almost indicate that the cells are something like a water bath. And I just want to find out if that is the intent of the specification writers.

SCOTT: I'd like to comment on that. Aside from the question of exactly how you do it, there is a strong interaction between the temperature of a cell and the capacity that you will measure under any given set of conditions.

In the past this temperature has not been very carefully controlled. And as a result there is usually a considerable dispersion or uncertainty as to what the real capacity is to any tight set of limits. And I think if we are going to improve our specification of capacity we must improve the control of temperature, and I don't think this is quite the proper place to get into a discussion of exactly how we're going to do it.

SULKES: I think if you do spell it out this way, then you do have to give them the method, because you still run into the same problem. If you don't specify a method that everybody can use, you'll get the same variations. A water bath or something like that is a valid

rms 74

method if this is what you want to use.

LANDSMAN: Landsman, MIT.

On this shake, we prefer to shake the cells more or less in the mountings that they will see in flight. And I would suspect it would be better not to have the battery manufacturer shake them, leave that up to the user, just let the battery manufacturer do the three -- the capacity tests at the three temperatures for the records, and then let the user shake and check after the shake.

SCOTT: May I comment? And then we'll have others. I feel that in every case the customer, the user, will have the option of indicating which of these tests are done at the suppliers and which are not and which he does. I don't think there's any implication here as to exactly who is going to do these tests and where. I guess this is subject to individual decision on each procurement.

RAMPEL: Rampel, General Electric.

8.6, Capacity at low temperature. From the standpoint of capacity the input duration of 30 hours may be sufficient, there's no question about that. But I think the voltage limit is a little high, 156. I would also like to recommend for consideration that some kind of overcharging of greater duration than 30 hours be incorporated at low temperature. We have on occasion found that in charging cells at 32°F for, oh, say, 48 hours and you rs 75

can continue on and eventually exceed a given voltage limit. And I consider capacity at low temperature to be a very important test.

HERZLICH: Herzlich, Sonotone.

It was mentioned here that one of the ways to perform the shock and vibration tests was to redo the test that the user wants and then repeat the test according to the specification.

I asked a question, isn't it reasonable to expect that the order in which you do the two tests is important. And by that I mean one shock test or one vibration test will influence the results of the second. And the second question I ask is: Having done two such tests, what can you really say about the cells?

SULKES: One basic question of philosophy in all these capacity tests -- and they are supposed acceptance or rejection tests -- is that there is no level set on how high cells can go. In other words, to achieve a uniform balance. What sigma limits would you want to set? Or should they be set? And I feel if you have a 34 ampere hour cell that they can spread from 34 up to 40 or 42. This is not the kind of cells you really want to use for a balanced battery, and perhaps you should have sigma limits on these things.

MAINS: NAD, Crane.

rms 76

I think one consideration that should be made is one the shock and vibration tests that you might possibly want to operate the cells to see if there is any effect during this period of time rather than looking at it afterward. Something might happen or might shift inside the cells that would be detectable during the shock or the vibration test that would not be exhibited after the test is completed.

GROSS: We all know that the effects of the initial cycling on cells changes the cells a little bit at the beginning of life. And it will make a difference as to whether we run these tests right when the cell is fresh or if it has a few cycles on it. I would expect a minimum of five to ten cycles would be required in order to obtain consistent results.

STROUP: Stroup of Goddard. In general, I would like to say something regarding our experience at Goddard in building a satellite battery, running the acceptance tests and doing much of the same things and looking at what is being proposed here in the specification. We have found that the numbers for end of charge voltage as in 8.4, in determining capacity to be completely unacceptable. I would say anything over 145 in our flight programs would be grounds for rejection of the cell.

I don't know where the 151 comes from. It may be

rms 77

a valid number, but we haven't found it so. The overcharge test under 8.8 calls out a voltage of 1.48 volts. This too is at the same rate of C/10 which is a rather moderate rate in our experience. It seems to be a rate that is common to most manufacturers, both as to space cells and as to commercial cells as a recommended rate for charging the cell in practice.

Maybe this makes it a good rate to use, since we have lots of data at the C/10 rate, it's a good reference point. This would be an argument for using it rather than a different rate which was suggested by some of our other people here today.

The 148 volts in 8.8 definitely by our experience on flight cells is at least 3/100ths of a volt higher than the maximum level that I would set for a flight battery. And from an electro-chemical consideration of gas generation the charge state of the battery at that particular time I think we all must agree not to be too nitpicking on this, and I mean it as a strictly scientific fact, that we generally must agree that about 147 from our experience is as high as we dare go on an overcharge level at that particular temperature and condition.

SCOTT: I have a comment on the comment there. I am wondering whether any of the manufacturers would care to comment on whether or not if we indeed are going to

rms 78

impose some strict voltage limits on charging in the final cell whether those requirements are going to have to be fed back into the process somewhere to actually control the manufacturing of the plates in some way.

CARR: Carr of Eagle-Picher.

Dr. Scott, in response to that, there are ways of changing the end of charge voltage. And in fact we have designed batteries deliberately with what we call a tail-up. This is to work on different types or a type of charge control, and it works quite successfully.

So, let's say we know how to make them to do this and we know how to make them to do higher voltages at the end of charge, higher controlled voltages at the end of charge, so that we just want to enter this into the minutes to be considered.

SCOTT: I'm informed by the chairman that we should break off at this time. So, I will turn the meeting back to Jerry. And he will tell you what is next.

HALPERT: As the next item, since we were a little early getting over/to the cafeteria yesterday, I've arranged for a 10 to 15 minute tour of our operations center. And Mr. Kelly is going to lead us on over. It is within this building area. It will take about 10 or 15 minutes and then we can walk on over to the cafeteria at the end.

Secondly, if you are interested in the specs on

rms 79

silver cadmium, to get a chance to look it over before tomorrow, these are available at the front of the room here, and you can pick one up.

So, at this particular point, let's break and we'll meet back here after the tour and after lunch at about 1:15.

(Whereupon, at 12:18 p.m., the conference was adjourned for lunch to reconvene at 1:15 p.m.)

AFTERNOON SESSION

(1:40 p.m.)

HALPERT: Gentlemen, may we take our seats, and we'll try to get started again.

I just want to make note of one item. We've decided for tomorrow morning's meeting that we will continue in here rather than in Building 22. And if any of you know people who are going to attend, or for yourselves, report back here. And we'll get a message out to the guards to transfer anybody who is scheduled to go to Building 22 to come in here instead.

At this point I would like to turn the meeting back to -- excuse me?

BILLERBECK: Excuse me, Jerry. Then tomorrow definitely will be on the silver?

HALPERT: Right. We hope to finish the nickel-cad tonight even though it takes until midnight.

How many people are planning to attend tomorrow -- can I see some hands, to get an idea?

(Show of hands.)

Okay. I'll turn the meeting back to Will Scott.

SCOTT: I would like to proceed, for the moment, to go through in numerical fashion the formal comments to section 8, and then we -- depending upon the time and all -- may want to return to an open discussion afterwards.

First of all, I presume possibly from the results of the earlier session, that there may not be any more comments specifically directed to the content of section 8.1.2. Aside from the actual requirements as called out in the following pages.

Are there any comments on section 8.2, Examination of Product?

(No response.)

I have some comments on section 8.3. Comment:

"We take exception to the electrolyte leakage test being performed using Cresol Red solution. It is our experience that this indicator gives spurious indications, and we would prefer the use of phenolphthalein as the indicator."

Another comment:

"This test is best performed during or after the cell has undergone an increase in internal cell pressure. Thus, this test should be performed while the cell is in the overcharged mode, or has been recently removed from charge and still has a residual pressure. If the cell does not build up a positive pressure while

ch charging at the C over 20 rate, the charging rate should be adjusted to produce an internal cell pressure greater than zero psi g."

Are there other comments from the floor on section

8.3?

THIERFELDER: Thierfelder, G. E. Space Systems. If the order which is listed here is the order in which the tests are to be run, I agree with the last comment, because the electrolyte leak test should be run after the cells have been on overcharge, and if not immediately during overcharge, at least following the discharge after that charge, because the leakage will remain there.

If it's a test for electrolyte leakage, the first thing you do when you get the cells -- or the first thing after you finish the cells, I don't think is too meaningful. It would have to be repeated later anyway.

BOGNER: Bogner, JPL. Perhaps the place to do it is 8.8.

BILLERBECK: 8.15 covers this again.

SCOTT: Yes. Mr. Billerbeck points out that section 8.15 calls for a second electrolyte leak test. I think the point is well made that one should try to conduct this test at least at some point while the cell is presumably under pressure. I'm not exactly sure how you're supposed to know that it is, or how much pressure, unless you have gauges on the cell.

But certainly the presence of pressure should increase the sensitivity of the test.

Comments on section 8.4:

"It is extremely difficult to maintain a 75 plus or minus 2 degrees F. during a capacity test without using the temperature controlled bath. The correct tolerances should be determined for an open bench type of test which is most practical when dealing with a large number of cells. Convection cooling would be added to the open bench test so that temperature excursions are kept to a minimum.'

Additional comment -- a suggestion for an addition to this paragraph:

"The variation in capacity within the lot of cells should not exceed plus or minus 7 percent."

Further comment·

"Also, the capacity as specified has an open ended tolerance. A maximum capacity should also be specified, which may vary depending upon the duty cycle the cells will have to undergo. This maximum capacity should be negotiated between the manufacturer and user."

It doesn't appear that I have any more formal comment. Is there any from the floor?

NIETZEL: Yes. I wish that we, as a group, would start to look at this paragraph. It seems to me that there is no necessity for a meeting here these last two days unless we do look at the capacity of a group of cells, and accept what we will set as a spec limit on cell capacity. We can have the best control in the systems, and if we end up with a product whose one sigma standard deviation is unacceptable, then we've gone noplace. We may by serendipity not know what we're doing, and yet have a product that does have a very tight tolerance. This is not beyond the realm of possibility.

We should, at this meeting, decide what will we accept for the capacity variation in a lot of cells, and we're suggesting at the one sigma limit, 2.3 percent.

I'd like to throw this open for comment.

STROUP: Stroup, of Goddard. One time we did have occasion to specify something just about of that order. The gentleman that had the problem -- two of them -- I believe one was Lou Belove, but they managed to achieve this range of plus or minus 2-1/2 percent on capacity.

But it wasn't without a considerable amount of effort. I don't know whether they'd be willing to address this in more detail to anyone or not. They did do it for us, and did a very nice job.

BELOVE: Belove, Sonotone. The cells that Gene Stroup was referring to were done by proceeding after a fashion that we have been discussing here the last two days -- that is, testing every plate and choosing those plates that were bound to give us close tolerances in capacity.

CASSOTTA: Cassotta, Bell Labs. We tend to -- I would very much support Mr. Nietzel in his plus or minus 2.3

percent, because this represents a pretty good lot.

However, I am asking a question. He said one sigma. Now, if you handle this with normal statistical methods, you usually accept everything within the three sigma limits, and we're going to be right back to 7 or 7-1/2 percent.

NIETZEL: Do you want another number then, Tom?

CASSOTTA: I would like to see that 2-1/2 plus or minus absolute.

SULKES: Sulkes, U. S. Army Electronics Command. There was some work done a while ago by Wagner at Yardley Electric on an Air Force contract to develop a nickel-cad and silver-cad cells with, I believe, a plus or minus one percent. And for the silcad this was achieved, and it was fairly closely achieved for the nickel-cad. And basically this involved individual plate testing and so on.

But it could be done, and it was done.

THIERFELDER: Thierfelder, G. E. Space Systems. I have some data here of actual numbers on a particular program. And this is a program using 419 cells.

On the various batches the capacity plus or minus variations were anywhere from 1.9 to 7.0 percent from the average.

And of course that -- and the average of the total was 5.0 percent, for the 419 cells. The three sigma limits would be 15.1 percent.

FLEISCHER: Thierfelder, will you tell us if that average is the rated capacity, or is that the actual determined--

THIERFELDER: These are variations from the actually tested capacity.

FLEISCHER: Now what was the rated capacity?

THIERFELDER: The rated capacity was 12 ampere hours. The actual average was 14.4.

FLEISCHER: Well which one are we talking about?

THIERFELDER: Well these are basic numbers on variations from an average.

FLEISCHER: I mean here, what do you understand that we're talking about here, in this 8.4? . . . shall equal or exceed the rated capacity. So we're talking about the actual here. All right.

SCOTT: I think there is a confusing use of words here at the end of this paragraph. The sequence, "rated capacity specified," I think needs to be worked over a little bit. Because rated capacity is usually a manufacturer's rating. Specified, I interpret this as specified by the user.

And so I'm not sure this is a compatible sentence right now. I think that whole business of rated versus actual is a bag of worms that is going to have to be resolved sooner or later. And I feel that really the only basis for talking about sigma limits and other control numbers must be on an actual measured value, and not have anything to do with a nominal rating.

So that rated capacity thing may be confusing there.

HENNIGAN: I would like to make a comment on the silcad batteries. We found years ago if we just bought cells, so many, if we got within plus or minus ten percent we were doing good.

Now we're built according to the blue book here, the spec, we can hit plus or minus two percent, but we still reject about 10 percent of the cells that do that.

GREEN: Green, Martin. I'm looking at this paragraph, and I see the intent of your last sentence is to make sure that your cell has the capacity you bought.

Now we're talking about variations above the capacity of the cell, which in the case of the manufacturer for his usual pad you get 20 ampere hours, and the most that we have received at Martin have been in the neighborhood of 24 or 25.

This excursion I don't think is so important from the standpoint of the cells themselves, but I believe it's highly important when it comes to assembling them in a battery. And under this condition, I see nothing in the index at least that refers to the assembly of cells. It would appear to me that we could take, say, a dispersion of 7 percent and as long as we used the low percentage in one battery and the high in the other, we accomplish something in the form of a balance between cells, which will give you much better action on charging and discharging characteristics.

While I'd like to see them as close as possible, I do believe that a little larger excursion doesn't hurt if you use a per cell selection. I see nothing about that in this test procedure, about giving information for cell matching or cell selection.

BOGNER: Bogner, JPL. I think we haven't expressed here how we terminate the volt, or the discharge. We say at one volt per cell. And I think most of this is usually done manually. A light may come on or he may have an operator standing there watching a volt meter. And you can have quite a large error or spread, just from a person not being there right at the instant it hits one volt.

And also these are usually run in a series of cells -- I don't know, 20 or 30 cells in a series -- and by the time a fellow takes that cell and removes the clip and takes it out of the circuit, by the time you get down to the last cell, it's got a longer run time when it actually hasn't been operating.

So this test probably should be run with automatic equipment.

STEINHAUER: Steinhauer, Hughes. There are several statements that have been made that the only way the closely controlled plus or minus 2-1/2 percent on capacity range has been achieved is by inspection of individual plates. I'm wondering if this is always necessary, or if by tightening the process it can be achieved without this 100 percent inspection, and if the people from TI would comment?

NIETZEL: Your process control parameters can be designed in such a way that when you make a group of cells, they will then fall into the specifications, without sorting as a function of assembling the cell packages.

Is this an answer? Is this the answer that you want?

STEINHAUER: I'm wondering if you're running a 100 percent capacity test on individual plates, or if your process inherently can produce plates that are within closely controlled categories?

NIETZEL: If by "plate," you mean the pieces of plate that are inserted into the cell, we do not check that -- no. We will take impregnated plate, cut to dimensions, and make a cell. And then if you make 100 cells and put them on the boards, your standard deviations will be within the limits that you desire.

There is absolutely no checking of individual pieces of plate prior to cell assembly.

HALPERT: I want to ask, Oscar, when you talk about that one sigma, are you referring to taking only those cells that were within that one sigma -- 2.3 percent -- is that what you said?

NIETZEL: The standard deviation of a lot of cells will be 2.3 percent. That's the total lot.

HALPERT: Well, that's not one sigma, then. That's three sigma.

NIETZEL: No, that's one sigma.

HALPERT: That's one sigma. Now you're only going to accept the cells in that one sigma range?

NIETZEL: I'm asking what you people want. What do you want?

HALPERT: Are you asking us here?

NIETZEL: Yes, because you're going to use them. What do you do when you finally put a group of cells together to make a battery? How tight do you select them? And why do you have to throw the rest of them away? Why don't y ou just buy the product to that spec?

SCOTT: I'd like to comment on that. First of all, I agree entirely that an upper limit should be imposed, in addition to a lower level on capacity.

I'm not quite sure that any or any one group can decide today on any individual number for what this dispersion in capacity should be. But I know that we have a great difficulty accommodating the spread like plus or minus 7 or 10 percent in capacity into most spacecraft programs.

This becomes even more difficult when you get into the area of systems containing more than one battery in parallel, where the characteristics from battery to battery now become critical.

And therefore, we must, I think -- at least I feel that if you're going to build systems in this way, and certainly some of these very large power systems that may be coming up for the space station and so forth, appear to absolutely require many parallel strings of cells, that the uniformity of characteristics of cells and batteries over a large number of cells have to be strictly controlled.

And I think this is going to demand a much tighter control on the capacity spread over periods of years of production -- not just a batch of 50, or a batch of 30 or a batch of 100.

And so I'm all for this approach. But I don't really know what those numbers should be. I think we probably have to look harder now at the procedures and requirements for cell matching, and translate those requirements back into the cell specification. And I don't think we've really done our homework on that yet.

So I don't really think we can hammer that out today, either.

FLEISCHER: I think it would be nice if the Bell Laboratory people would tell how they selected their cells for matching in the Telstar program. As I remember, it wasn't only capacity, but recharge voltages and various voltages. It is rather difficult to tell from the report exactly what the criteria were that were combined. But they have already done this, and maybe their experience could help in settling what things ought to go in here.

CASSOTTA: As I recall, the parameters that we used at the time were end of charge voltage, for one. This was at room temperature, following a 16-hour charge at a C/10 rate. It was the end of charge voltage, following a 16-hour charge at the C/15 rate at 32 degrees F. It was the discharge capacity at room temperature following the charge I described, through a one ohm load, and a similar discharge capacity through a one ohm load at 32 degrees F.

We looked at the overcharge potentials at the end of -- and I'm not certain of this, this is the one that I'm kind of stabbing at. This was way back, Art, and I haven't look at those numbers recently. But I think two weeks was the period that we used.

We also made what we arbitrarily decided were internal resistance measurements, and self-discharge measurements. Then we took each of these parameters on the group that we had measured them on, and constructed distribution plots of each of these parameters.

And based on the distribution plots that were constructed and the cells appearing within a band which we arbitrarily selected, this is essentially how we went about it.

STROUP: We do very much the same thing. We put more weight on the -- in our flight batteries -- on the overcharged voltage that we do on the capacities. Capacity ranges in actual flight batteries have been plus or minus seven percent, perhaps, at the gross condition. The capacities don't seem to work too much against us in the actual operation of the battery.

The big problem is having overcharged voltages uniform between cells when you put them in the battery. So I would say that the overcharged voltage, from my experience, is by far the more important single item that you can look at when it comes to selecting cells to put into a space battery. And this is one reason why before I had commented on the stipulation of the 1.51 voltage at room temperature, and the 1.48 overcharge voltage at room temperature.

Now I'd like to say just a little bit more about that. On the radio astronomy satellite Explorer battery which was built at Goddard, the mean overcharge voltage of that particular package was on the order of 1.41 at room temperature, 1.41. And the spread was on the order of 1.40 to about 1.43 -- over about 90 percent of the cells fell in that range. That's on overcharge.

FORD: One thing that has been overlooked in this testing is the fact that are you going to run most of these tests, electrical tests at least, still looking at the pressure characteristics of the cells. I think in too many cases this one characteristic is let fall by the wayside, when in fact it becomes very important, particularly where you can observe over a period of several tests a trend in a cell to show stable pressures, or a cell to show continuously increasing pressure over several test sequences.

I don't think anywhere in this spec it is mentioned that the gain should be left on the cell throughout the electrical test. Granted, the mechanical test is something else.

But I don't think this information should be overlooked. It goes one step further, as was mentioned yesterday, that there is another consideration I think is important and we should begin to look at it very hard -- is the recombination rate of oxygen in the cells become a criterion also for cell selection.

SULKES: Sulkes, U. S. Army Electronics Command. One point that the gentleman from Bell brought up that would perhaps be quite a good test -- and I'd like to get some opinion on it -- would be a use of either a capacity loss on stand, or let's call it a charge efficiency test, where you perhaps only charge up to 90 percent of capacity, and then see what you get.

If this would be some sort of valid test of perhaps how much nitrate is in the cell, and what efficiencies they do have. This might be an important characteristic as well.

GROSS: Gross, Boeing. We mustn't lose sight of the fact that there are two things that distinguish. One is the problem of getting good, uniform cells to begin with, and the second is the task of selecting from that group the best matching that we can.

Certainly you can get matched capacity to any specification if you have a large enough sample. But to me, the important virtue in specifying close tolerances on capacity is that the cells will have the best chance of having been made in the uniform way, so that they will age in a uniform way. And they will behave pretty much together.

You certainly would not expect that if you have a very large variation of capacity and then select from that group the best cells, even though the capacity is the same, they certainly would not age the same.

THIERFELDER. Thierfelder from G.E. I think we're over-emphasizing this capacity measurement by quite a bit. I've found in actually going back over the results of life tests that there was no correlation between the life of a cell and the capacity of a cell when they were new. In fact, in an awful lot of cases the ones that had the best capacity were the ones that failed first.

And I found that there was much more sensitivity in a test when you cycle the cells -- for example, specifically, we cycled cells for 20 cycles to some given depth of discharge, and at the end of the 20 cycles, completely discharged the cells.

And what we then called the -- I forget the name -- the capacity from the end of the last cycling discharge down to 1.5 volts, this could be correlated to some extent to the life of the cells. This was on the Nimbus program.

But to try to correlate life versus the original capacity, there was no correlation at all. And to think that by getting the highest capacity cells we're getting the best cells, I think this is very misleading.

SCOTT: I don't believe that I heard that we are striving for the maximum capacity. I agree with you that the highest capacity for a given size cell is not necessarily the most desirable thing to have. I think that a controlled capacity is more desirable.

And there is also a possible impact of extra high capacity, cell capacity, a possibly adverse interaction of that with excess negative capacity; because the higher the positive, presumably, possibly the lower the excess negative capacity is going to have to be.

So certainly I think that, again, there should be an upper limit as well as a lower limit on the capacity specification.

STEINHAUER: Steinhauer, Hughes. I'd like go on record as concurring with Dr. Scott's earlier comments on this subject.

We're putting into a spacecraft, on both the charge control and on the discharge load sharing. Each spacecraft has its own characteristics. We may need closely matched end of charge or overcharge voltages, depending upon the charge control technique that is used. We may need extremely uniform discharge capacity, depending upon whether it's a single bus spacecraft or multiple bus, depending upon how these batteries may load-share.

Right now on two of the spacecraft that we have in progress we're using a battery cutoff voltage, or we design to a 117 or 115 volt per cell on a battery. But this is an average, to end of discharge.

We look to very closely matched cells to be able to do this on a battery basis. We don't want to have to sense individual cells.

So, all I'm saying is that this specification cannot state what would be required for each spacecraft or any in general. I think we have to come up with some general characterizing and classification of the cells that would be required overall. But these paragraphs are going to have to be amplified for each spacecraft application.

FORD: Ford, NASA Goddard. I'd like to make a further comment on that. In fact, it goes so far as to say that for every spacecraft application your cell selection criteria should necessarily be different.

For example, in synchronous orbit it is not uncommon to see depths of discharges in excess of 40 percent, and even possibly in some cases up to 70 or 80 percent.

Certainly in this case cell matching in capacity becomes very important, as contrasted to a spacecraft in a 200 nautical mile orbit, where you're only using 15 to 25 percent of the capacity.

Another example is a situation where you may have low charge rates available, and your range of C/30 to C/40 consistently, throughout the life, I don't think it really gains you much to match capacity at a C/10 charge rate, when throughout the life of the cell it's going to be C/30 with a 40 charge rate.

So, to tie this specification into cell selection and cell matching, I think is out of the question. Because each application has to be considered in its own light, and the certain requirements that are associated with the application.

GASTON: Gaston, Grumman. I'd like to go back to Mr. Ford's earlier comment, and I certainly agree with him about the overcharge characteristics for the voltages are very important in cell selection. On the OAO batteries we have used a distribution curve with the various overcharge voltages at three different temperatures. And we also compared the pressures. And based on that we have selected the cells which were most closely matched. And I strongly believe in the paragraph 8.8 in the overcharge test, that in addition to 75 degree overcharge, a lower temperature overcharge should be added to see the recombination characteristics at lower temperatures.

SCOTT: Well maybe I'd like to take this five-second gap to get back on the track a little bit here. Maybe if we have time at the end we can come back to talk about some of these more philosophical questions.

I don't mean to say that they're of no importance, but I believe, as was earlier stated, the intent of this section was to provide some examples of generally applicable acceptance tests that might be useful in comparing cells made by a given process, regardless of what their end application was, and regardless of what the specific requirements for cell matching charge control and other characteristics for a given application may be, I'm not certain that there is any one set of completely acceptable, universally applicable acceptance tests.

But this is what we're exploring right now, and this is a first cut. Certainly these cannot be expected to be the substitute for actual, individual cell tests to design a battery for a specific application.

I have some formal comments on the combination of sections 8.5 and 8.6. Comment:

"The most practical method for testing a large number of cells is in these cases a temperature chamber. Again, convection heat transfer is used and under these conditions a tolerance of plus or minus two degrees F. is insufficient. It is requested that the tolerance be opened up after determining what can be obtained."

Again, on 8.5 and 8.6:

"Both sections appear arbitrary in the selection of these test temperatures and current densities. If the end use of the cell requires operation at temperatures other than 75 degrees F., then the operating extremes should be the test temperatures. In this manner the cell operation at the duty cycle temperature is measured. Similar comments also apply to charge and discharge rates.

"Also, this test procedure will impact directly on cost and delivery of the product, since the manufacturing cycle is extended and additional labor is required."

Other comments?

FORD: Ford, NASA Goddard. I'd like to ask a question -- if there would be any response to it.

As standard procedure for the manufacturers' representatives here, does anyone normally run any tests at other temperature than room ambient? I'm not talking about the test specified by the customer -- I'm talking about of your own choosing. Do you run tests at other temperatures, other than room ambient?

RAMPEL: Rampel, General Electric. Yes, we do. We run high and low temperature, in that order.

RUBIN: Rubin, T.I. In terms of normal in-process testing, as this specifies, we only test 100 percent -- to a 100 percent level at 75 degrees F.

SCOTT: Paragraph 8.7. Comment:

"Is there any significance to the 5C rate and does it reflect the maximum all cells have to perform at?"

Any further comment on that?

(No response.)

I may comment that in the light of the definition of what this was intended to do, I guess it may be obvious now that this was not intended to represent any specific usage, but only a number that is useful for characterizing the high current capability of the cell, and in a general manner, for comparative purposes.

FLEISCHER: Does this mean that the cell is to be discharged for 10 seconds at 5C, or that it has to be at one volt minimum for 10 seconds? I don't quite understand what this means.

BILLERBECK: I think it was intended to mean that after 10 seconds of discharge, that the voltage should remain above one volt. And I think this is typical -- that this requirement stems from squib firing in the spacecraft.

BELOVE: Belove, Sonotone. As I recall the origin of this test, it started with some of our first cells. In the cylindrical cell, with a two-plate cell, at that time there was some difficulty with welding. We were never quite certain as to whether there was a weld established at the bottom of the cell. This has since been changed. But at that time we established a high-current, 10 second test. And we read the voltage after 10 seconds, and through that, established whether we had a weld or not. Because at the high rate you could usually determine the difference between a good and bad weld.

At this time we see no reason for it in our cells and I think in others too, because welding has been improved. But in the early days this is what it was used for.

FORD: Ford, NASA Goddard. This type of test is normally run as standard procedure on flight hardware after environmental tests.

SCOTT: Paragraph 8.8 -- is there some other question?

(No response.)

Comment on paragraph 8.8:

"Does this test reflect what is required of the cell during actual operation? It could interfere with a cell design where maximum electrolyte fill levels are desired, and where the actual application does not require extended periods of overcharge. This type of test is best coordinated with a 'conformance to duty cycle' specification, and would include the extremes of operating conditions."

That's all the formal comments I have. Are there others?

RICHARDSON: Richardson, Marshall. On 8.10, on the shock test, we at Marshall don't normally shock test flight hardware that we're going to fly. Normally the shock test is only performed during your qualification test, where you want to qualify a basic design of a component, or a black box, or whatever it might be - - or a cell.

It seems to me this wouldn't be desirable, to run a 100 percent shock test on all your flight cells -- not unless there's an application where they're going to be repeatedly shocked.

I don't know -- maybe you have this in mind.

SCOTT: I think we skipped over paragraph 8.9. If you'll bear with me to keep this thing in order. I don't have any formal comment here on 8.9. Are there any others?

GASTON: Gaston, Grumman. There is apparently some alternate procedure to this charge for five minutes and let stand for 24 hours. The alternate procedure is to apply a one-ohm resistor for 16 hours, and let the cell stand for 24 hours, and then measure the voltage build-up. We have found this a very sensitive test, and possibly more sensitive than this test procedure.

I would like very much to see the alternate procedure included in here.

SULKES: Sulkes, U. S. Army Electronics Command. One thing that appears important -- these tests should definitely be specified by order. As Floyd just pointed out, this high-current discharge appears to be a very good test after your shock and vibration, if it does pick up things like weld failure.

The same thing with the charge retention, where you may induce a short. You might be able to pick that up after shock and vibration.

But the order of tests I believe is extremely important, and should definitely be specified.

GASTON: Gaston, Grumman. I have an additional comment on paragraph 8.9. I think the temperature should be specified.

GROSS: Gross, Boeing. On 8.9, I would think that the title of the -- the title "Charge Retention" is not perfectly correct. It's basically a short test. You're testing to determine if you have a short.

STROUP: Stroup, Goddard. On that 8.7, before we get too far away from that, I want to say one thing. The 5C rate discharge for detection of bad connections, while I would it is a very good test, for certain cells, that would not hold true in my opinion as well as you would like for it to hold true for other cells. There are some cells that will, for instance, withstand a 30C rather than 5C rate, and still be better than one volt for a period of 10 seconds without any problem. Sonotone has made many of these, by the way, and I imagine they're still doing it. And of course other manufacturers are making cells that easily do 10 seconds at better than one volt at a rate of around 20C.

FORD: I would like to make a general comment in regard to paragraph 8.9, for information purposes. We are currently involved in-house in a program to look at both this type of test, charge retention test, and the other type of test we refer to as the open circuit voltage recovery test. And as Steve indicated, we found out that both tests are very sensitive to temperature. They are also somewhat sensitive as to how the cells are discharged. They are also sensitive to whether the cell has been cycled many times previous to running this test.

So my comment at this time is that we have two tests available to us. Both of them have certain limitations that I think we all should be aware of. And I'm not sure we know at this time what all these limitations are.

It was very surprising to us to find out that regardless of which test you ran, there was a difference in open circuit voltage recover that you got after cycling, as compared with after a recondition cycle on a fairly new cell.

GROSS: Gross, Boeing. We should recognize in paragraph 8.7, in a high-current discharge test, we should recognize that the small cells will have much greater capabilities for high voltage at high discharge rates. The large cells, especially the very large cells, will find this a very difficult test and probably not necessary.

So the high-current discharge rate should really be related to the size of the cell.

RAMPEL: Rampel, General Electric. 8.9, Charge Retention. I would like to suggest a compromise situation between the open circuit recovery and the C/10 for five minutes and drop to C/10 to C/20.

CORBETT: Corbett from Lockheed. The label on 8.9 reminds me that I see nothing in here that's similar to a charge retention test -- that is a test of whether the cell holds its capacity for a period of days or weeks or so. And since there's been a lot of discussion in this particular spec concerning impurities, and since this has been related to the amount of capacity that a cell holds for a period of time, I think this might be a good performance test to include as a measure of whether the cell is good under those conditions. That is, some sort of a test for perhaps a period of days, to see what the -- how much capacity had remained in the cell, and perhaps decide upon a fixed percentage of rated capacity which would have to remain in the cells for a period of stand at perhaps an elevated temperature.

FORD: Could I clarify your suggestion, that on a 100 percent basis --

SCOTT: I have a comment to that. It seems to me that that is getting pretty close to a highly applications-oriented type of test, because in my knowledge there aren't too many batteries, nickel-cadmium batteries, being used in such a way that they are required to retain much charge on open circuit. Maybe I just don't know about them, but if they are not, then it seems to me possibly somewhat academic as to what the long-term, open-circuit charge retention is.

CORBETT: I guess I would have two comments to that, Dr. Scott. One is that I think it's a good performance test which indicates the general health of the cell; whether or not there happens to be an application for it, this is important.

And another point is that this is related somewhat to the efficiency, and we have seen considerable variation from cell to cell of the charge efficiency, which I think is something that is undesirable from the systems standpoint for an orbiting spacecraft -- particularly low orbiting spacecraft.

The second point is that usually when you're sitting in a spacecraft on the pad, it may be for usually more than two to three days, and I think it's an undesirable feature to have to continually trickle the battery, or at least you wouldn't want to have to depend on that.

Also, in synchronous orbit, it requires two to three days for a vehicle -- if I understand that problem correctly -- for a vehicle to get into the orbit that it's meant to be in. And I think this is equivalent to the kind of stand time that you need to meet for the application.

SCOTT: Other comments?

(No response.)

So now we're back to 8.10, Shock Test. Steve?

GASTON: Gaston, Grumman. I agree with the earlier comment from the gentleman from Marshall. I believe if I will run shock tests on cells at an earlier point, I might find them later on rejected by the systems people, having over-tested my units. So I'll be somewhat cautious about adding shock tests at this moment. Because as far as I know, most flight units are not exposed to shock tests, pre-qualification tests.

SCOTT: Excuse me -- may I interject some of the written comment here, which I failed to do earlier?

Comment:

"We are uncertain as to the need of an 80_g peak during shock test. Perhaps we can be enlightened as to the technical need."

And then on 8.10 and 8.11 combined:

"If these shock and vibration tests are general enough to cover most operating environments, then these sections are acceptable.

"Also, this type of testing, if performed on a 100 percent of the lot, would directly impact on costs, since it requires more direct labor and would also lengthen delivery time."

And then further, on 8.11:

"In general, we find the vibration levels rather high and more in line with qualification type levels rather than cell acceptance. Is there some particular reason for extending these levels?"

If there is no comment we'd better proceed here.

I have no comments here on 8.12. Are there any others?

FORD: I have a comment. I feel like that following the cell being subjected to a leak test of this type, it should be followed by a chemical leak test.

SCOTT: I have some comments on 8.13. Comment:

"We generally use X-ray techniques to determine the proper location of internal components, and for showing the absence of foreign materials. It would require 7 or 8 views on each cell to determine weld integrity and at that would be extremely difficult on a completed cell.

"We suggest that the question of X-rays be something which is negotiated between the manufacturer and his customer."

Further comment? This section must also include the minimum acceptable resolution as specified by a minimum detectable particle size. Measurement can be effected by using a penetrometer. Particles 0.10 inches in the smallest dimension can readily be detected.

Any comment from the floor? Steve?

GASTON: Gaston, Grumman. I agree with the earlier comment which says the weld joint -- to detect the weld joint integrity, or the weld joint failure by means of X-ray -- or weld joint defects by means of X-ray, is not a practical method. I don't think it can be conducted on a large scale. We tried it and we were not too successful.

However, you can detect impurities, particle sizes. And we have a 10 mil size arbitrarily as the rejection criterion. Any particle which can be seen outside the spec integrity, around the edges or the tub, inside the cell, this is subject to rejection -- any particles larger than 10 mils.

RICHARDSON: Richardson, Marshall. You say you defined particles in there you can -- where are you seeing these -- up above the plate area?

GASTON: Above the plate area, and you see it on the edges or the sides.

RICHARDSON: We've had some experience at Marshall X-raying silver cells. We ran into a little problem where we were getting short, and so on, and we, in looking into some of these cells, on the edges of the plates going in on an angle X-ray, you can actually see bent corners of the plates.

So we started X-raying all cells on one of our stage programs, on the corners. I believe that was the only two places we were looking at. We didn't go on a full X-ray of the cell, like, say, look for particles that were loose up there.

So we wind up rejecting cells if we see something in the X-ray there that might look like it's bad, we just automatically reject the cell. It may or may not be the cause of a possible shorting, you know.

GASTON: Yes, we are considering the whole X-ray as established. At the moment we are not able to determine whether this is a metal particle or any other particle. That's one of the difficulties. Now if it's a non metallic particle, apparently it's not subject to shorting. But the metal particle would be. So we will have to reconsider that, the whole X-ray analysis.

RICHARDSON: Now in only one case -- we have one type of cell that's got a narrow plate, and it was shorted at the Cape. And in the failure analysis we went ahead and, since we knew the general area in the cell, because the case was warm, we X-rayed there, we could actually see the particle embedded in between the plates. It was a silver particle.

But here again, if you had to do this on a production basis you'd have to take about 8 or 10 shots so that you could look perpendicularly, right parallel to the plates. Because you'd be unable to take one shot and look through all the plates. It would be quite an expensive process to do it as an acceptance test, to take 10 X-ray shots of every cell.

And then here again, you may or may not see it.

GASTON: Yes, I agree it's not a perfect method in production. At the moment we're only taking three pictures. We take two views prior to sealing and one view after sealing. And we have detected some particles. We haven't quite established what they are, whether metal or not. But we have seen particles larger than 10 mils, and we have not used those cells.

May I ask you, in the silver-zinc cells, was that plastic case or metal case?

RICHARDSON: Plastic.

GASTON: Oh. With a metal case it's even more difficult.

RICHARDSON: Yes, I can imagine it would be horrible going through metal, and especially if you're trying to evaluate let's say the weld on the tab, if you've got cracks or anything. Most of our X-rays are of weld joints, you know, on the stages, and here you're putting the film maybe right behind the weld joint, and you get a pretty good shot at it. And we even take angle shots. We're looking for porosity, internally in the weld joints, and the cracks, and porosity with sharp tails and various things of this nature. And that would be real tough, trying to find this internally in the cell at your tab area, I would think, to look for a bad weld.

GASTON: Well, I agree it's not a perfect method. But even an imperfect method is better than none. So I'd like you to look at it a little bit closer and see what we can come up with in this X-ray technique.

RICHARDSON: Then you have a question of evaluation. If you see something there, you should have standards for accept or reject; and here you get into all kinds of problems of what people see. And people have different machines they use that sometimes vary. And being able to resolve certain items in the X-ray. And some films they'd be less dense than others. And you'd get into quite a problem with X-ray interpretation in this area.

So you have to be awfully careful, I think, when you determine accept or reject criteria when you're looking at X-rays - unless it's something obvious -- you've got a blob in there that you can obviously see.

SCOTT: May I comment? How long are you guys going to carry on here?

GASTON: Just one more comment. In case of doubt I'd much rather reject one more than one too little for flight batteries. We might take a perfectly good cell and reject it because there would be a shadow in there.

But it is an additional tool that I like to use and I'd like you to explore it a little bit more.

SCOTT: X-raying of cells, nickel-cadmium cells in steel containers, is not something that is new. TRW has been doing this for years and years. We've gone through all the agonies that you have just recited. Indeed, they are many.

The net outcome is that we still firmly believe that the advantages outweigh the disadvantages. I could recite the whole story for anybody, if they have time. We have worked out as quantitative a standards, methods of evaluation and so forth as the state of the art permits. All this has been implemented, is being used, and so it isn't something that we're just tossing in here. I think it's something that has demonstrated definite usefulness from the point of view of the user.

A more detailed comment: We routinely obtain a pretty good view right between the plates of a nickel-cadmium cell, and can pretty well see through almost all the plates on one, single shot -- right down through the separator. It's not perfect, but you don't need 3 or 4, 5 or 8 views at all.

If you back off far enough, use the proper conditions, you can split the plates -- even through the steel container. It's just a matter of deciding you're going to do it, and it's worthwhile.

So, there's a chunk of technology here, I think, that's worthwhile looking at.

NIETZEL: Nietzel, T.I. I'd like to concur with Mr. Gaston, that particles as small as 10/1,000ths can be readily detected by X-rays.

SCOTT: 8.14. I guess I have combined comment on 8.14 and 8.15:

"These steps are readily performed, but they will also impact on cost and delivery time of a given lot."

That's all the formal comments I see here. Any others?

(No response.)

I guess that wears that out.

GASTON: May I make just one more comment please? On paragraph 8.3, on the electrolyte leakage test. I'd like to suggest after washing the plate with a water, I think it's specified, to have a vacuum bake added to remove any water which is outside the cell and which are on terminal areas. Some terminal designs have a cavity which is open to the exterior and which is covered with plastic. There is a possibility that a water trace could penetrate through this and cause possible corrosion.

We have added as a safety feature, we have added a vacuum bake.

STROUP: Stroup of Goddard. Did anyone make a correction on the leak rate on 8.12, from 10.6, the helium leak rate -- shouldn't that be 10 to the eighth?

HALPERT: You're talking about changing 10^{-6} to 10^{-8} there?

STROUP: Yes. I wasn't coming up with anything new there. This correction has been made at other points throughout the document. And certainly, if you're going to be consistent, then you would have to continue with that one.

HALPERT: Okay.

STROUP: I would like to say one other thing on that. I would like to make the observation that if you have two cells, one cell that does not leak that has helium in it, and one cell that does leak and is supposed to have helium in it, that you'll get the same result on tests, with this particular test. That is, both of them will show good fields.

HALPERT: If there are no more comments, I'd like to move that we take a break here. And I will mention that there is coffee in the back as there was yesterday. We also have copies of the specifications for zinc plates and for silver plates down here; if you haven't picked up a copy and you'd like to scan them over before tomorrow's meeting, they're available.

I would like to resume -- keep the time to fifteen minutes at the very most, so we can finish up as early as we can this afternoon.

So let's come back rather quickly, please.

(Recess.)

HALPERT: Gentlemen, please take your seats. We have something to cover and we would like to cover it before it gets too late.

There was a comment about number 8 that Floyd Ford wanted to make before we completely close out that section.

FORD: Yes. The comment is in reference to 8.9, Charge Retention test, or whichever one results.

This type of test is somewhat sensitive to the pressure applied to the broad face of the cells. In other words, the cell should be constrained in a configuration under pressures that are somewhat similar to the conditions that it will be subjected to in a spacecraft battery, when this type of test is run.

HALPERT: Okay. If there's no comment about that, that will complete section 8 and we'll go on to section 9.

Section 9, just by way of introduction, is -- we call it a sampling for production cells, and taking those cells apart and doing an analysis of the materials in the cells.

This sounds like a duplication of some of the earlier work and some that may not be required -- that should not be required since you've already constructed these cells based on given specs.

But I think it's a matter of assuring, at the beginning, anyway, of assuring -- giving us confidence that what we are really producing -- we are going into these cells and are looking like they're supposed to after they have been assembled into a final product.

I'm sure that's one of the first things -- that after the spec has been utilized to some extent and we have a lot more data, I think this is one of the first things that will be reduced considerably.

But I would like to read a couple of comments I do have in general. I don't have any specific comments about any of the items in there -- just two general comments on the entire area.

> "Regardless of which of the specified tests are performed, there are no dimensions or tolerance levels specified. In general, a large amount of data will be generated without any immediate use of a parent plan to use this information.
>
> "Also, the need in general of these tests is questionable. If the previous testing of plates, electrolyte and separator has been performed, these tests become redundant and costly -- up to five percent

increase in the finished cell price. There are no specific comments other than those previously made regarding method and types of analyses."

Second comment:

"The sampling procedure of using a minimum of five cells could be extremely expensive on a small production run. Although we consider this an excellent experimental program to determine potential changes due to electrical use of the cells, we are not sure that this is justified in procurement type of contracts, and it may be better done in a controlled experiment."

Those are the two comments I have on Section 9. Does anybody care to make a comment about the necessity -- the use of this type of test in a specification?

HENNIGAN: I would like to make one comment here, I think, in the separator area. I think that this is one area that should be looked at after the cell has been used.

HALPERT: Any other comments regarding number 9 at all? I will not cover the individual sections. We have two pages in which much of the analyses is done similarly to what has been done before on the basic materials.

Again, the intent here is to assure that we have the materials in the cells that we intended to put in there, and to make sure that nothing has changed in their manufacturing process. No question or comments concerning number 9?

REED: Reed, from Battelle. I have a question about the intent of paragraph 9.2.7. It says, "Using the plaque from Paragraph 9.2.5, determine the strength of sinter. . ." and so forth. 9.2.5, this is the one in which you've just performed a metallurgical reduction on positive plates.

Do you want this strength of sinter and surface area determined on the reduced plate, or on something else? It's not clear to me what you have in mind.

HALPERT: In 9.2.7 when we're talking about the plaque that's left after the extraction -- and in 9.2.5, we're talking about the plate before we do the extraction. This tells us something about the corrosion.

GROSS: Gross, Boeing. In 9.2.7 it will be found that the plaque has corroded in a very non-uniform way,and this will present problems. Some areas will be very much changed and other areas will be changed to a lesser extent.

NIETZEL: Nietzel, T.I. Jerry, I believe what you mean here is that the plaque from 9.2.6 -- that is what you would use. You take 9.2.6, which is the plate, extract from that your active material, and then take the resultant plaque and go back and look at your sinter strength, surface area, pore volume, pore size distribution -- and then you would try to compare that with the initial plaque used prior to impregnation.

HALPERT: That's right. It's 9.2.6. That's correct.

NIETZEL: Then that should be 9.2.6.

HALPERT: Right.

NAGLE: An additional step that you might use here that would give you information in section 9, would be to determine where your cell balance is before you take the thing all apart; find out where your cadmium is, what kind of a ratio you have between positive and negative.

HALPERT: I think that may be discussed a little bit further, in 10.

Are there any other comments concerning section number 9?

(No response.)

Okay. Then we'll go on to section number 10, the sampling of production cells - electrode capacity test. And I think Dr. Scott is going to stand in here.

SCOTT: Section 10 describes a tentative method for determination of the electrochemical capacity of the positive and negative electrodes in a completed cell.

Comment 1:

"We question the minimum value of the negative to positive capacity ratio of 1.5."

This is regarding, I guess, paragraph 10.0.

"We would again like to see the technical justification for this value and wonder if control experiments could bear this out."

Again, comments on 10.0:

"For those plate manufacturing processes which do not normally provide these data, this testing procedure is desirable, but will increase the price. Its major benefit is the measurement of the distribution of negative capacity. The range and distribution of positive capacity will be determined on a cell basis also in some formation procedures."

Another one specifically regarding 10.0:

"A negative to positive ratio of 1.5, based on flooded formation testing is considered an arbitrary value, since the need for excess negative capacity and its distribution is effected by the following:

(a) Charge rate

(b) Discharge rate

(c) Temperature

(d) Overcharge rate

(e) Degree of overcharge

(f) Life

(g) Plate loading and thickness.

The amount of and distribution of negative capacity is considered a design parameter which is selected based on the duty cycle."

End of formal comments on 10.0. I would like to say that I don't believe that during the formal discussion of comments on this section that we should get into a big hassle on the exact criteria. I think we will probably come back to this when we finish the more routine discussion of these things, and I feel that this is indeed a difficult question, of what this ratio should be, and why; and getting into that discussion now would unduly prolong the finishing of the normal business at hand.

So I would suggest we want until we finish, and then come back to this point later.

Other than the actual numbers that we are aiming for, are there other kinds of comments on 10.0?

(No response.)

10.1, Sampling Rate. I have no formal comment on that. Are there any other?

CARR: Carr, Eagle-Picher. Excuse me, Dr. Scott. I have just one comment regarding the sampling rate. It seems, since this is considered a destructive test, and we're talking about a 10 percent sample, or some other sampling basis -- but these are pretty high numbers and do increase the cost quite a bit.

SCOTT: Yes, I believe that possibly some maybe more statistically digestible sampling plan could be appropriate here. It certainly -- I think that the actual percentage should be a function of the test lot size and other process considerations. So this is a rather arbitrary number right now, subject to negotiation.

RAMPEL: Rampel, General Electric. The electrode capacity test in 10.0 is very dependent upon the sequence of testing before it -- the history -- particularly in regard to what you're going to find in the way of electrochemically active cadmium.

So it's important to spell out conditions beforehand, the history.

SCOTT: I believe that is done to some degree in 10.2. Are you saying that that's not sufficient?

RAMPEL: No. I see you have it covered.

SULKES: Sulkes, Army Electronics Command. One question -- is this test on a completely random basis, or sort of use the ones that are just not that desirable?

(Laughter.)

SCOTT: I guess I don't understand the question.

SULKES: Well, in other words, it doesn't call out a completely random basis, and if I was the manufacturer and I had to make a subjective judgment, I would give the ones for this test that are, let's say, slightly out of voltage or slightly out of spec -- or within spec but out of tolerances on capacity -- in other words, that type of thing. You would try to save your best ones for your actual flight batteries.

SCOTT: Any comments? It seems to me that if statistical sampling is done honestly, it cannot put up with any shading of that kind, and you'd pick, presumably, as many good ones as bad ones.

On 10.2, I have some comments:

"To assure uniformity for lot to lot testing, the value of 5/C ohms should be based on C equal to average delivered capacity of the lot of cells."

Any further comment on that?

FORD: Ford, NASA Goddard. If I interpret that correctly, it means every cell, or every lot of cells, may be run at a different current rate, and consequently a different current density?

SCOTT: That would be the way I would interpret it.

GROSS: Gross, Boeing. Relative to the last comment, I would personally prefer to see the rated capacity closer to the delivered capacity, and continue to use rated capacity for a great many of the tests that we do.

But there is a problem if the rated capacity has too great a range.

SCOTT: Paragraph 10.3. Comment:

"The cell should be discharged without the addition of electrolyte, since this increases the efficiency of the electrode and will yield higher usable cadmium metal levels than would be usable in the starved condition. On charge the cell can be operated under a partial vacuum to remove the evolved hydrogen and oxygen."

That's all of the submitted comments I have. Are there others?

(No response.)

I might just mention one correction, or maybe a couple, which may or may not be obvious. In Section 10.4, the expression for (T_{P_3}) should read "Time from start of discharge."

And down here in the third from the last line, the expression for excess capacity of total negative over positive, there should be brackets around the difference between (T_{N_3}) and (T_{P_3}).

And in the last line, there should be brackets around all three terms following I_O.

SULKES: Sulkes, Electronics Command. I started looking at these equations, and maybe somebody else has found it too who can explain it to me -- but it would appear that last relationship should be $(T_{N_3}) - (T_{N_1})$, and there should be no need for positive capacity at all, in there.

SCOTT: Well, because this is a calculation of excess, it's excess relative to positive. So positive has to be deducted.

SULKES: Well, first, shouldn't it -- wait a minute --

let's see, (T_{N_3}) -- in other words, you're charging your cadmium up completely, fully; then discharging it, getting it's full capacity; whereas, (T_{N_1}) is the actual negative capacity, as it was in the cell; and therefore, it should give you that excess discharge negative.

SCOTT: I can see there's a typographical error here. One of those two has to be (T_{N_3}) in the last line. Obviously, they can't be both the same. I missed that.

Offhand now, I don't know -- it must be--

BOGNER: Shouldn't it be (T_{N_3}) - (T_{N_1}) - (T_{P_3}) --

SCOTT: So the first one is (T_{N_3}), not (T_{N_1}). Does that help?

SULKES: Well, let me just say the term is right, though, if you put that P capacity in. In other words, you've got two negative capacities, and the difference between them should be what exists normally as uncharged cadmium -- cadmium hydroxide. That's your excess. There should be no P term in there. I don't see why --

BOGNER: Bogner, JPL. Maybe changing the terminology of the terms -- it might be nit picking, but it might be more understandable -- if you called the first term -- just call it (T_{N_3}), total negative capacity; next term, call that excess negative capacity; and the third term, on charge negative capacity, or excess active cadmium hydroxide. These might be more logical, easily understood terms.

SULKES· One other correction. In step 3, I believe the first minus one volt should be plus or minus -- the plus or minus sign should be reversed on the one volt terms.

SCOTT: I guess I missed that. What --

SULKES. Step 3, your voltages should start off plus one volt, plus 1.5 and so on. The last term should be minus 1.0. It's probably just a typo -- transposing the pluses and minuses on the one volt.

SCOTT: Yes, that's correct. The first one should be plus one, the last should be minus 1.

Do you have something you would like to open the discussion with now, on this section? Or do you want to -- what would you like to do?

HALPERT: Let's finish up the section, and then we'll go on and --

MC CALLUM: I had a question on paragraph 10.2, where it talks about 5/C ohms; I don't recognize that unit.

SCOTT: That's a new unit; I invented it.

(Laughter.)

I don't believe that one ohm is appropriate for all size cells. I think it's going to give you a different result with every different capacity. So I think you need to relate that load to the capacity of the cell. And that's my approach -- I'm just suggesting that.

MC CALLUM: As a dimension of reciprocal hours --

SCOTT: Well, you know how this term C is used. Everybody uses it in different ways. This is just -- I'm not trying to make the units consistent here. I've never been able to figure out how to -- what a C/2 rate means, in terms of units. So, it's just a number -- it's a resistance which is numerically equal to 5 ampere-hours over the rated capacity in ampere-hours.

FLEISCHER: Well, what you have is 5 ohms per ampere hours. If you have a one ampere-hour cell, you have 5 ohms per ampere-hour. It's ohms per ampere hour.

MC CALLUM: That isn't what he means.

FLEISCHER: Yes it does. That's what he means.

MAURER: It amounts to that.

FLEISCHER: You mean if you have 100 ampere-hours cell you take 5/100 for your resistance? Don't you?

SCOTT: That's right. I think when you're talking about a small range of capacities of cells, like 6 to 12, or something like that, it may not make a difference. But when you're working with a range of 6 to 100 I think it makes a great deal of difference.

HALPER: May I get a a clarification of that? This means that if you had a one ampere-hour cell, you'd be using five ohms for a one ampere-hour cell, is that right?

SCOTT: Well, that would be the logical --

HALPERT: Okay, and if you're using a 100 ampere-hour cell you'd be using 5/100?

SCOTT: That's right.

HALPERT: Smaller resistance.

SCOTT: That's right.

HALPERT: I'm sorry. It's in the right direction.

(Laughter.)

SCOTT: Well, doggone you --

(Laughter.)

SCOTT: Do you want to open the discussion to the business of what the negative to positive ratio should be?

HALPERT: I want to finish number ten.

SCOTT: Okay.

GROSS: Gross, Boeing. I just want to point out the typo error in Step 2. On the "greater than" signs, you want cell voltage greater than 1.53 here I'm sure, and you want to get more than -- greater than 50 percent hydrogen.

HALPERT: Which paragraph is this?

GROSS: 10.3, at the top of the page -- step 2.

HALPERT: I'm sorry, you'll have to repeat where you are.

GROSS: Paragraph 10.3. Step 2.

SCOTT: That's correct.

GROSS: Second sentence -- "Cell voltage should be greater than 1.53 volts."

HALPERT: Okay.

GROSS: And "gas evolved should contain greater than 50 percent hydrogen."

HALPERT: That's less than 50 percent.

GROSS: Yes -- I presume that you want it the way I just read it.

SCOTT: It should be "greater than." That's correct.

HALPERT: It should be "greater than."

GASTON: Gaston, Grumman. Just one suggestion. Since I think we all know what C means, but maybe for clarification it should be defined in definitions of what C means -- just for clarification.

HALPERT: Are there any other comments regarding section number 10?

FORD: Are we coming back?

HALPERT: Well, we'll finish number 11 and then we'll get into some more open ended stuff that we haven't --

FORD: Okay.

HALPERT: -- finished yet. Okay, for number 11, our illustrious chairman, Mr. Billerbeck will handle.

BILLERBECK: Well, we should be able to finish this one very quickly, since we have no written comments on this section. And I think it's a very simple thing, and the intention of the section is just to ensure that the cells are prepared and packed for shipment in a manner so they don't get damaged.

Perhaps the simplest thing to do is just ask if there are any comments from the floor on the first page, 11.0 through 11.6.

CARR: Carr, of Eagle-Picher. With reference to 11.2, is there any real reason to ship a cell in a short-circuited condition?

BILLERBECK: I'll try to answer that. I think that there is a possibility of short-circuiting during mechanical inspection, which would be avoided if the cell is in a shorted condition when shipped.

GASTON: Gaston, Grumman. A suggestion on paragraph 11.2. This "discharged" here implies there's a possibility the cells might be charged and have to be discharged. Maybe the discharge regime should be referred to in some earlier paragraph. And maybe -- "short-circuited condition" -- maybe the means of how a cell should be short-circuited should be specified, like a copper wire wrapped around it.

And another suggestion on paragraph 11.3, the unit packaging. Maybe the cell should be placed in a heat-sealed polyethylene bag prior to putting into the container. And maybe each container should be marked on the outside at least with a serial number.

Another general suggestion is that all cells should be stored at as cold a temperature as possible -- I should say as cold a temperature as possible -- cool temperature. For long-term storage.

BILLERBECK: Any other comments on 11.0 through 11.6?

GROSS: Gross, Boeing. On 11.2, I would appreciate hearing from people who might know, whether there is a difference between being shipped or stored for a long time, short-circuited, or versus stored fully discharged, but open-circuited.

I recall having heard that there is a difference, but I have no facts. And if there are some facts, I would certainly like to hear about them.

BILLERBECK: Any comment on that?

HENNIGAN: One of the reasons is to keep that voltage off the seal so we don't have any corrosion in storage. It was very helpful, I think, when we had one seal on there. But this is done as a matter of practice now.

FORD: Ford, NASA Goddard. Right on here I don't see any indication of a high temperature limit. In shipping, these cells could be put in a cargo hold such as the temperature would exceed -- could be extremely high. There may even be a possibility of separator damage if the temperature got too hot. I think this should be mentioned.

BILLERBECK: Any other comments?

SULKES: Sulkes, U. S. Army Electronics Command. In regard to Floyd's comment on temperature, there are these temperature labels which can be bought for a very few cents, and can be applied to these individual cells, and will give you an indication of how high the thing has gone. In other words, you can set a limit of 160 or 180, and it will indicate if it has gotten that high.

BILLERBECK: I think that we can move on to the next page, and - - 11.7, through the end of this section. Any other comments on that, from the floor?

(No response.)

All right. Fine. I think I'll turn the meeting back over to Jack Halpert then.

HALPERT: Okay. I think we're covered the specification as well as we can, by number, at this particular moment. And before I get into some general points, I did want to make this announcement again. We will be meeting here in this room tomorrow morning at nine o'clock, and I'd like to get started on time at nine tomorrow.

We only plan to go until one o'clock, in terms of talking about the silver spec, the zinc spec, and the silver-cadmium spec.

So those of you who want to make your reservations and check out of your motels can plan to be out by one o'clock.

Second of all, if you haven't picked up the specs and you want to take them back with you this evening, there are still copies sitting here, and I do also want to make note that if you have not put your proper address on that sign-in sheet, there's still the chance to make the proper changes down here so that you do receive a copy of the minutes of this meeting when they are completed.

Okay, at this point, I'd like to open for some general discussion, and I would like to do it in the following manner. I have received permission from there of the manufacturers to read some general comments of theirs with regard to this specification, and their feelings for it. I thought you users and the Government people, might like to know how they do feel about it, and this may be a chance for you to hear how they feel and maybe ask them some questions about these feelings. Number one:

> "Gulton Industries is deeply appreciative of the importance of nickel-cadmium batteries for the space program. We are more than sympathetic with the objectives of the above specification document and welcome the interest and concern of the parties involved in this preparation. We have always attempted to impose the maximum practical amount of control and selection of materials, processes and testing, to obtain maximum reliability and performance, compatible with reasonable

costs and acceptable time periods.

"We believe, however, that this document as presently written, imposes standards and levels of control on testing which are probably beyond those required to assure maximum reliability and performance, and are impractically expensive and time-consuming.

"It is our recommendation that specific programs be initiated to explore many of these areas and the results used to implement or modify the present document. We have made specific recommendations in this regard to NASA Goddard, Electrochemical Power Section, and others, with the cooperation of certain of the prime contractors, and NASA has achieved some results which are considered in a specific comment which we will offer.

"Nevertheless, if mandatory, we can and will meet the specification as written, given sufficient time, money and equipment. However, consistent with the invitation to which we are responding, we intend to comment specifically as listed in the attached outline."

And some of the comments given today are -- and yesterday -- are relative to that.

As to the General Electric comments:

"Both the General Electrical technical personnel and the cognizant management people have read and studied the subject specification very carefully. Each subscribes to what we believe to be the intent of the specification, the assurance of aerospace cell reliability.

"General Electric's battery business section recognizes the desirability of specifications which incurs the production of spacecraft type nickel-cadmium cells in a well-controlled, reproducible manufacturing process. We see this as the goal of the interim specification.

"However, we are concerned about the means proposed in the specification to ensure repeatability. First, we are concerned about the numerous tests to be made with no limits. We interpret this to mean that a later date the same test is to be made on another lot of cells and the results are expected to fall within the same general area. This method of specification has the drawback of exposing a vendor's complete processes and process controls to the public.

"We believe this type of data, relative to our manufacturing process, to be proprietary information and will be forced to take exception to such a requirement.

"Using this particular specification would increase the procurement lead time for cells and add materially to the cost. The General Electric's battery business section has procedure in place aimed at achieving high reliability and repeatability. It is a well-documented and controlled process, incorporating a system which we call an indentured parts and process list.

"This list is tied to a specific catalog number unit which in turn is tied to a specific customer specification and/or requirement. Each step in our process either has been written up or is being written up and the controls and method of testing, to assure proper processing are in writing. The contents of these documents are deemed proprietary; hence they are not sent out of the plant. However, they are available for the customer's examination at this location.

"The indentured parts and process list can be supplied to the customer on request. This list covers all the process documents, the number of the document, the number of the process control document, along with the date of issue and the particular revision number pertinent to this cell.

"With this system of documentation, in fact, we believe we are well on our way to meeting NASA requirements. Although we are well on the way there, there is much work yet to be done. We would like to meet with NASA Goddard and discuss a program aimed at refining the documentation, making the system adaptable to any vendor's process without creating a need to divulge proprietary information."

The third comment I have is from the SAFT Company, who is tied of course, as you probably know, to both Gulton and the G.E. process. General comments:

"In addition to comments concerning specific paragraphs of this specification, we would like to offer the following general observations.

"SAFT believes the specification to be a significant achievement in the development of detailed processes and control requirements for the manufacture of nickel-cadmium cells for space applications.

"However, we question whether all the measurements, tests and controls which are included are required during the production of quantities of cells. It appears to us that all of the imposed requirements do not have the same importance with respect to the quality of the final product.

"Therefore, we suggest that this specification in its totality be initially utilized to qualify a process and its resulting products, to determine critical controls and measurements and define acceptable limits.

"Then, a second specification could be written applicable to the production quantities, which incorporates only those controls found to be critical to achieve the required performance and reliability. It would be unnecessary, for example, to determine the spectrum of porosity on as many samples of the spiral if it were found that this parameter varies very little, or has a small effect on the cell's characteristics.

"The above recommendation is primarily based upon our estimate of the cost to manufacture cells, utilizing all of the controls outlined in this specification. The installation of the equipment and procedures for production quantities would require a considerable investment, difficult to calculate at this time, which would have to be amortized in the price of the cells.

"We estimate that to conform to all the requirements of this specification in production would increase the price of the cells 6 to 10 times the present price for space cells.

"2. It is our opinion that it is impossible to meet the specification without permitting the sorting of materials and components at various points within the manufacturing cycle. For example, the basic materials such as the substrate bands, nickel, cellulose binder, and separator, have characteristics which vary according to lots.

"In addition, the sintering and impregnation processes have not been entirely mastered, and the characteristics of these products are dispersed. With present technology it is possible to obtain satisfactory average values, but not possible to reduce dispersions. Am improved process control would definitely improve the products, but again would not diminish the dispersions within the limits outlined in this specification.

"Therefore, we recommend that at various steps of the manufacture, prior to taking samples for test and analyses, the components be sorted. This sorting would thus produce the 'lot' which would continue through the manufacturing cycle. The samples taken from the lot would then be tested to ensure that the sorting was done correctly. This point is discussed further in our comments on paragraph 2.4.2.

"3. Based upon the above remarks, we believe that the manufacture of high-reliability nickel-cadmium cells could be developed and realized in the following manner:

"Complete analysis of the manufacture of one lot, utilizing the controls and measurements provided in the specification.

"Determination of the critical points of the manufacture and the characteristics of the components which have a bearing on final cell performance and reliability.

"Definition of the controls and measurement limits necessary in the production processes and components by classifying the defects in categories of different importance in order to arrive at the criteria for rejection.

"Application via production specification of these controls to the production and test of component parts, allowing for sorting at various points in the process.

'Assembly of the cells, utilizing a controlled process.

"Control of testing of cell lots, using a sampling procedure without any sorting being conducted. Any non-conforming lot would be rejected in its entirety.

"The approach which we are suggesting differs from the approach taken in the specification, in that, (1), it allows for the sorting of components at various levels of manufacture, prior to taking samples to determine conformity; and (2), it decreases the number of controls utilized in production and thus decreases the cost of the batteries without sacrificing cell performance or reliability."

Those are three comments from three manufacturers. I did not ask specifically for any other comments. We did ask -- and those who are attending, if they would like to make comments, we certainly would accept them. I wonder whether T.I. or the Sonotone people would want to say anything at this particular point? I didn't give them any warning, so they might feel -- and Eagle-Picher -- pardon me.

CARR: Carr, of Eagle-Picher. That was almost like a commercial.

I really think that our feelings toward the specification have been presented here in the discussion. I do want to say that we're here to support it, and we want to help in any way we can to arrive at a higher reliability battery.

BELOVE: Belove, Sonotone. My comments -- like we've made several comments during the course of the two days, and our feeling is that the product is important enough to warrant putting additional effort in.

However, as we said before, if it's half an effort, we might as well leave it as it is and do the best we can under the present conditions.

On the other hand, as I mentioned in a letter to NASA, we at Sonotone would be happy to work with them in promoting the state of the art of nickel-cadmium batteries for space work, because we firmly believe that this will benefit not only NASA, we as citizens, but we as manufacturers of a product, of the nickel-cadmium battery.

HALPERT: At this point, if there are any general comments from anyone regarding the subject of how we would intend to reach these goals that we've discussed in these specifications, and the problems to be encountered in doing so --

(No response.)

It has been suggested that we open up this discussion again to the problem of making a ratio measurement -- a negative to positive measurement, and I wonder whether anybody would care to start off the discussion again along this line.

FORD: I'd be glad to open the discussion. In regard to this ratio, I'd like to make a general comment; that in the past three months, from two different sources, failure analysis has indicated that the capacity of the negative electrodes after long extended tests is essentially the capacity that is attained from the positive electrodes.

I can specifically refer you to a report that came out of Battelle, Dr. McCallum is probably aware of the one I'm referring to, and also recent failure analysis that came from Crane.

I will also indicate two manufacturers' cells were involved here. And I at this point firmly believe that most of the cells that we have cycled at Crane in long term test programs ultimately become negative-limited.

The fact that the negative capacity does fade, and the extent of fading, is a function of the environment and the condition the cell is subjected to.

So the technical justification for a minimum ratio is certainly within our grasp today. The exact number for each manufacturer may also vary. But at this point, I think a ratio of 1.5 in most of our applications that we have in mind for the next 2 to 5 years, and even in the 10-year program, is certainly going to have to be held up.

GROSS: Gross, Boeing. Your remarks must be interpreted to mean then, that the problem is not one of determining the ratio; but the problem is one of developing a better negative electrode. This is where the muscle is needed.

FORD: That would be a solution, but we have to live with what we have today. In order to live with that, we have to start out with a minimum amount of excess negative capacity in a cell to get a certain cycle capability.

One other addition I'd like to refer to, is the work that one of the manufacturers here today has been doing for NASA Goddard over the past year. And the need for an adequate excess negative versus cycle conditions has clearly been demonstrated in this contract, on which the final report should be coming out shortly.

I think the technology is here, and the information we need to look at these numbers is currently available to us. And to me, this minimum ratio of 1.5 for long-term capability, particularly at temperatures above 160 degrees F is real.

RAMPEL: Rampel, with General Electric. The ratio of 1.5 minimum that you're referring to, Floyd, is I take it, effective negative/positive ratio as measured in that test in paragraph 10, and not necessarily the actual rated negative/positive ratio that you might find on -- during electrochemical cleaning?

FORD: Yes, I'm referring to the electrical capacity.

RAMPEL: The effective negative to positive ratio; during electrochemical cleaning it would be expected to be much higher. Because later on, when you do it in section 10, as Dr. Scott pointed out before, the cycling history, whatever it might have been, would have generated inactive cadmium, which would not be measured during the test in paragraph 10, where you're measuring the 1.5.

FORD: Well, I think if you'll look at the steps where the samples are taken, that requirement applies to a finished cell that is to be delivered to the user.

RAMPEL: Okay, so that is effective negative to positive ratio, and actually you would have to go in at a much higher ratio on the raw plaque -- plates, is what I'm trying to make understood.

GROSS: Gross, Boeing. I would certainly hate to see the manufacturers achieve this requirement by loading their present negatives to a higher depth. There has been work, and I believe Bell has done such work, that would point to perhaps a lesser loading as being a better way to achieve the end result.

It's not a simple question that can be resolved simply by loading a plate heavier.

SCOTT: Scott, from TRW. In that regard, I believe if we are smart enough we should devise some way within this testing procedure of measuring the rate of change of negative capacity during cycling, and therefore, the stability of it, and give some sort of a specification to that stability over a number of cycles.

I don't know exactly how to do it, but I think that's the point that you're getting at, too.

MC CALLUM: I wanted to ask about this 1.5 ratio that Floyd just mentioned, and it's in paragraph 10.0, where it says 1.5 minimum. Whereas this morning we were talking in paragraph 7.4.3.(g) of 1.3.

FORD: There is still a misinterpretation to the latter paragraph, of 1.30. If you read that paragraph very carefully, and how it applies to the paragraph above that, all it says is that the negatives will be discharged a minimum of 1.3 times the capacity attained on the positive electrodes.

That does not mean you have depleted the negative electrode of its terminal capacity. The idea there was to leave precharge in the negative, but additional information has indicated that this may not necessarily be the desirable thing at this point, and perhaps it is most desirable to work with these negatives in a complete discharged condition.

HALPERT: Is there anybody that believes that pre-charge is not necessary? Does anybody believe that pre-charge is necessary?

(Laughter.)

BOGNER: Does anybody have any data, showing one way or the other?

SULKES: Sulkes, U. S. Army Electronics Command. One question is when we talk about ratios of 1.3, 1.4 and so on, as Dr. Fleischer has pointed out, there is roughly a 20 percent loss. In our present cells, today, we're probably, I would guess, running ratios of 1.1, 1.05 to 1 as effective, whereas Floyd now is trying to take it all the way up to 1.5, which may be perhaps a little bigger job than is actually justified.

And -- I don't know if there's enough data to actually justify it at this time.

HALPERT: Are you talking now about Signal Corps operation, where you do have some --

SULKES: No, even in space, where in other words your -- most of your cells are, what -- roughly 1.5 -- as material put in. But when you take your 20 percent loss and several other factors that occur -- oxidation and so on stand, your cells that you have tested and done these failure analyses, may have actually started out with very low amounts of cadmium in excess. And therefore, you may not be really justified in making as big a job as you're actually doing.

HALPERT: Any other comments with regard to this?

FORD: Yes, I'd like to go a little bit further on this justification, in saying that cells which have been built with this minimum ratio -- at least approaching this minimum ratio, have worked satisfactorily for over a year.

In addition to this, the overcharged voltage of these cells at 0.0 degrees C., under standard test conditions, not necessarily the ones described in this spec, have remained fairly consistent throughout the cycle life on a 90-minute orbit which has completed almost 5500 cycles now.

So, what I'm saying is that experience is my only evidence that I can tell you about.

In regard to the gentleman from JPL, we are currently looking at the effect of pre-charge on these cells. I think I mentioned this to you earlier. And I can tell you in a very short period, cells that do not have any pre-charge when they're started on cycling, show a loss of capacity. But I have to point out, this capacity can be regained quite readily by simple re-conditioning of the cell.

On the other hand, cells that are started on cycling with a high level of pre-charge show up with high voltage in hydrogen generation. And this occurred within 600 cycles.

HALPERT: Floyd, on the cells that you discharged, were there any differences in the characteristics of the cells if you didn't discharge them all the way down? In other words, if you're not worried about capacity, you're just going 15 to 20 percent depth, is there a significant difference?

FORD: The only difference you can tell, without completely discharging the cell, is eventually in the over-charge characteristics. Cells with low level of pre-charge plates on the negatives, do not show any significant change in the over-charge voltage -- even at low temperatures.

To answer your question -- no, you could not see the loss of capacity, unless you took it all the way down.

HALPERT: I meant was there any other change, other than that, due to the fact it didn't have any pre-charge?

FORD: None that I could put my finger on at this point.

SEIGER: Seiger, of Gulton Industries. I'd like to ask a question. In those cells in which you fully pre-charged the negatives, did you notice any change in the positive capacity as well?

FORD: No, none that I would say that were significant. The positive capacity, following the reconditioning cycle on all the electrodes, were very uniform.

SEIGER: Before the reconditioning, did you notice anything?

FORD: On the initial capacity discharge, the cells with no pre-charge showed a loss in capacity of approximately 6 to 8 ampere-hours. The cells with two different levels of pre-charge, one being relatively high -- incidentally, I'm not saying we fully pre-charged all the cadmium, because we in no way knew what the total amount of cadmium was in excess on those cells. The cells that we put some pre-charge in, showed a slight reduction in positive capacity. But there were three test samples -- zero pre-charge, four ampere-hour pre-charge and eight ampere-hour pre-charge.

The four and eight ampere-hour pre-charge showed about the same reduction in capacity with the cycling.

FLEISCHER: What was the discharge rate in those?

FORD: The cells were being cycled at 25 percent depth.

FLEISCHER: No, but the rate?

FORD: C/2.

GROSS: Gross, Boeing. I would like to ask the question, has anybody had unfavorable experience with cells with high negative/positive ratios? Ford has indicated bad experiences with cells with low negative ratios and has cited an example of a case where a cell of high negative ratios was good.

If there are examples where cells have had high negative/positive ratios which didn't behave well, then this would be important to know.

RUBIN: Rubin, T.I. To answer your question, Sid, first of all, you can't just talk about high negative to positive ratios, per se. You have to discuss, in addition to that, the loading level of the plates which includes the porosity, pore size distribution and thickness of the plate.

In certain application, one has to maintain a very high negative to positive ratio. And this is done most effectively by loading the positive plate less than you would normally do. If one maintains the loading levels that you normally -- and I put that in quotes -- use in space applications, that loading level, if you increase the negative to positive ratio by increasing the negative plate loading, per unit volume or per unit area, then we have experienced high pressures and a substantial amount of fading in a very short period of time.

I don't have the specific data in front of me, so I can't really comment on how short a period of time it was -- on the order of 20 cycles.

HALPERT: Do you have a comment about that?

RUBIN: One additional comment. You will find, I believe, in the power sources conference, a paper presented by Dr. Yost and Dr.Pulpet of Texas Instruments, where they describe some of the effects of heavily loaded negative plates.

CARR: Carr, of Eagle-Picher. In answer to Sid's question, the batteries which we have used in orbiting spacecraft, or that we have furnished for these vehicles, have a relatively high negative to positive capacity ratio, and it is our experience that we get quite good results. And in addition, there were tests run which Dr. Fleischer mentioned earlier -- the four different manufacturers -- and our cells were particularly strong in the deep depths of discharge.

HALPEPT: Are there other comments about negative to positive ratios, pre-charge, overcharge?

Well, is there anything that anybody would like to present at this time? In a way, we've kind of talked ourselves out today, but I want to give anybody who wants the last word, the last word.

STEMMLE: Stemmle from Goddard. Floyd's presentation of the problem leading up to the negative to positive ratio reminded me of another problem I heard about, a problem which developed with life of a cell; namely, that they appeared to dry out. And I just checked back on the electrolyte section, and I was wondering if we ought to give some consideration to the optimum amount of electrolyte to optimize cell life.

HALPERT: Do you have any comment regarding electrolyte, and quantity of electrolyte?

CORBETT: Corbett, from Lockheed. Yes. I'd like to endorse Mr. Stemmle's remark -- I'm thinking back, and I'm kind of surprised we ignored that whole issue, because if anything is important to the overcharge voltage, it's the quantity of electrolyte. And it's also the size and the permeability and so forth of the separator, and the way it happens to wed out with the electrolytes. So I think that's the most important thing, perhaps -- next to the positive ratio -- next to the negative/positive capacity ratio problem.

HALPERT: I think it's one of the areas we certainly want to look at, but we'd like to find out some numbers that we could put into the spec. We'd like to measure how much we will put in there, and how much really goes in and is utilized, and how much is there later on.

But I think that's part of the -- not a part of the specification -- we'd like to be able to put a number into the specification. We certainly would like to measure what would go in and come out.

Any other comments? Dr. McCallum?

MC CALLUM: I would like to make a little commercial here on behalf of the Columbus Section of the Electrochemical Society. Next February it is sponsoring a two-day symposium on battery separators. John Lander of the Air Force now, is putting the program together. Dr. Reed has a few copies of the program, and I wanted to make sure you're all invited and knew about this.

HALPERT: I have registration sheets here. Are there any other comments or questions?

FLEISCHER: Jim, will you say what kind of separator this drying out referred to?

STEMMLE: As far as I know, it was a standard line nicad cell, so I suppose it's a Pelon separator.

GROSS: One more question. Gross, Boeing.

I would like to invite comments on the subject of the nickel-plated substrates. The specification prefers that the substrate be pure nickel. I would like to know what information is available about the harmful effects of the steel.

HALPERT: Well, some reading I had was that iron does become a contaminant in cells, and at one time -- and this is quite a long time ago in some of this earlier work, I think there was a comment as to iron causing ferrites -- that is, the contaminant of iron causing ferrites in the cell, which had some harmful effect.

Now, how that relates to the present situation, I'm not quite really sure, but just the fact that it did have an effect in those days is one that we might want to consider for now.

In terms of the nickel actual adherence, in some of the photos that we've taken -- metallurgical photos that we've taken of the nickel screen, nickel-plated steel and pure nickel sheet, we found good adherence of the nickel particles to those materials. So, in terms of that kind of adherence, I would say that particle growth is adequate. In terms of what actual problems the iron does cause, that is, at the moment, still a question mark, outside of that one comment.

FLEISCHER: If you want, I can recall some experiments that we did for Fort Monmouth, which had to do with the effect of iron in the positive plate. And this is in sintered plate. But this is in the flooded condition.

I don't care to extrapolate to the starved condition, but I'll give you a rough rundown on some of the experiments.

We added iron nitrate to the nickel nitrate for the impregnation in various amounts, and we determined the performance of these plates at various rates of discharge. And we found at the low iron concentrations -- and I can't give you the range, whether it was one or two percent of the nickel -- but we had a linear relationship between the loss of capacity and the amount of iron.

Now, the thing that led me to do this work was the fact that in those days we used all nickel-plated hardware. We did use nickel screens. And the iron content of the electrolyte in these cells was always 0.6 of a part per million. No matter what we did we always had 0.6 of a part per million.

The next step was to use all pure nickel hardware. And now what happened, as soon as we started to cycle the cells the iron content disappeared, and that was it. There was never again iron over a period of something like 200 cycles at one cycle a day.

On the other hand, the ones that had nickel-plated hardware always ran at 0.6 of a part per million.

We analyzed, at the end of the cycling period the active material from these plates, which had been cycled with nickel-plated hardware. And the iron content fell right on a straight line for the loss in capacity for the same number of cycles.

So apparently iron does have an effect on the nickel electrode when you have a flooded electrolyte.

HALPERT: One more comment along that line. Floyd reminded me of some six ampere-hour cells that we took apart not too long ago, and I'm not exactly sure of the history -- Floyd might have a better recall of that -- but we found significant amounts of iron deposits on the terminal post of, I think it was the positive electrode, but I'm not certain. But there was significant deposits of iron.

CARR: Carr, of Eagle-Picher. Just for whatever this information is worth, we ran some tests using some iron material in the cells. The only real thing -- this was done on vented cells, rather than sealed cells -- we noticed one peculiar effect which I can't explain -- I would say I haven't investigated it -- and that is that after a hot stand, such as 160 degrees, charged for four days, we saw after this, a temporary loss of capacity which was much greater than on cells with pure nickel material in them.

This was mostly -- there were a number of different types of iron introduced, iron tabs, for example, instead of nickel tabs.

SULKES: Sulkes, U. S. Army Electronics Command. I believe the mechanism that's claimed is that the iron lowers the oxygen over voltage on the nickel, and therefore your charge efficiency should drop. And in space cells, particularly, where you may have low charge rates, this could cause a significant problem.

And I believe there's a patent somebody -- it was beryllium additives or something like that -- to help against this very problem.

THIERFELDER: Thierfelder, from G. E. I just want to make the observation that the cells on the Tiros satellites, the Nimbus satellites, have gone well beyond four years. These are cells having nickel-plated steel substrates. So they've gone at least four years and they're still going.

FLEISCHER: What was nickel-plated?

THEIRFELDER: The substrates.

HALPERT: Well, if there are no other comments at this particular point, I would like to thank you all for coming to these nickel-cadmium session of the specification. We appreciate your coming great distances, from the west coast and so forth, and we hope to see -- as a matter of fact, our panel members here, and everybody who did join in the discussion, and our microphone helpers there on the sides -- we really needed them.

We look forward to seeing many of you tomorrow on the silver-zinc and silver-cadmium section of the specification.

Thank you very much.

(Whereupon, at 4:37 p.m., the meeting was adjourned, to reconvene tomorrow, Friday, October 31, 1969.)

RJM
CR 9487

rms 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS

Building Number 3
Goddard Space Flight Center
Greenbelt, Maryland

Friday, 31 October 1969

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P R O C E E D I N G S

HALPERT: I want to welcome you all here this morning to the third session. I want to make a couple of announcements here, if I may. Anyone who has not signed this sheet with the proper address, please do so to make sure you get a copy of the minutes of the meetings. And if you do not have copies of the three specifications on the zinc, the silver and the silver cadmium, since we'll be talking about these today, I'll be glad to make sure you do get one.

Does everyone have copies of these?

As you see our panel of experts has dwindled. I will turn the meeting over to Tom Hennigan.

HENNIGAN: First we would like to cover the Goddard spec for sil-cad cells which is really a combination of Yardney specifications and Goddard specifications. Yardney said they would not attend the meeting. They are in agreement with the specification because it has been used and they only had a few comments on it. Mostly typographical errors.

This spec has been used in part, and as we found problems we rewrote the spec for about the last four to five years, so we have a lot of the numbers for the spec requirements. A lot of it is just to make sure that the process is under control.

rms 3

I would say before we used such a specification we had quite a bit of difficulty in getting flight quality cells. And now we can buy a lot of several hundred cells for several satellite programs and maybe we get about 10 percent rejection. It's just rejecting some because they're a little bit out of capacity or their voltage characteristics might be a little bit different than the others, so it has worked out very well.

This specification is for a dry cell. After we receive the cell, we fill it with electrolyte, do all the formation, sealing and fabrication of the battery.

According to the spec, Yardney is the only supplier, and it says in here some place that they are the recommended supplier.

I want to bring on Ed Colston here who will go over the spec with you. If you have questions, we will try to answerthem for you. Ed Colston of the Electro-Chemical Power Sources.

COLSTON: There are two things that I think should be said before we start going into this. One is that for these specifications we have found it is essential that you work closely with the manufacturer,get into his plant, be on friendly terms with him, know his process. And in some cases we've been up there during manufacture, this sort of thing.

rms 4

Also, if you are military or NASA, there is probably a D/CAS man at the plant. You might get on friendly terms with this gentleman too. He is a military type QC man who stays at the plant and inspects your lot. And if you talk with him and work with him and tell him what to look for, we've generally found that they are very helpful.

The next point is that this is the way we buy the cells. We've done it very successfully for about the past seven years. If you don't like this or think it is unnecessary or have your own way of buying it, that's fine with us. This is not an attempt to say let's all buy them this way or this the way the industry will do it, because basically so far Goddard is just about the only purchaser of secondary spacecraft silver cadmium cells.

We would look forward to any comments or opinions in this session -- philosophy or anything like that -- on these various sections.

Now, on page one, we use these specifications for buying three, five, ten, eleven and sixteen ampere hour cells. We then list applicable documents. And then we say a general requirement is that all these cells be manufactured in one production run. We found this very useful. One production run has turned out to be acceptable when a run made a half year before that was not acceptable. A satellite

rms 5

using a certain production run gets into trouble, if we have cells from that run, we feel that we can test them and say something about the satellite battery.

Unless otherwise specified, these requirements in here are 100 percent inspection. We're going to look at and we're going to weigh, we're going to measure every plate.

Now, this does increase costs and time. But it seems to be worth it. Out of one of our lots that we get in we can take 20 cells usually, form them, and get 13 or 14 cells for spacecraft batteries.

We've known other groups that in order to get -- what was it -- 18 cells, they had to use a lot of 50 to 60 cells. So, by increasing the QC requirements to 100 percent inspection we have reduced the number of cells that needed to be bought or expended.

All right. Under components, 3.2, the first one is a general type statement about the stock electrolyte solution. This comes into the factory at about 45 percent solution.

On the next page we have the chemical requirements. The first one is left blank, the potassium hydroxide concentration by weight because although it is usually 40 percent solution, this can vary if you want something special. We just say plus or minus one percent.

Then for the potassium carbonate and the chloride

rms 6

and the carbonate and the iron, we have listed specifications.

Then for the silver we have listed density, particle size and electrical utilization. Now, on the electrical utilization I am told that this 2.6 grams per ampere hour is a very low figure, that it's very easy to meet this figure, and it possibly should be raised.

By the way, that we know of we haven't had trouble with the silver powder or the silver plates particularly. Now, for the cadmium oxide powder, the cadmium oxide powder shall be free flowing --

FLEISCHER: That's the point I wanted to ask about. I have never seen free flowing cadmium oxide powder. For example, you can't screen it. You have to use special devices for doing it. It will not pass the Hall test which is used in powder metallurgy. I've never seen any free flowing cadmium oxide.

COLSTON: Well, we've had two groups of cadmium oxide powder that we've seen. One type was pourable. The other type tended to clump together and stick together as though it was damp. There seemed to be some sort of moisture or something in it that was causing it to stick together.

FLEISCHER: Well, I've seen all kinds of cadmium oxide powder because it is used directly in the pocket type plate. And it is not free flowing. It has to be pushed.

rms 7

And it will not pass the Hall test which is the standard for free flowing powders. It is even worse than carbonyl nickel powder which will also not flow. So, I was sort of surprised when I saw that expression.

I don't know, maybe it has changed in the last two years, but I've never seen any free-flowing cadmium oxide powder.

HENNIGAN: Well, it is weighed out into a cup when the girl pours it into a mold, and it seems to flow out of the cup evenly. As long as we don't run into a processing problem with it. As we mentioned one time it did start to clump on us. The girls could use it, but they had a heck of a job making these plates.

FLEISCHER: I'm talking from the experience of going through this of trying to find out how to measure the properties of cadmium oxide for the pocket type nickel cadmium production. And, for example, I thought at first well this is a matter of very small amounts of moisture. So, we dried them at different temperatures over a long period of time. No, it didn't make any difference.

I see your point that you use it for a special thing where you can label it and spread it. I don't know whether that would have any relationship to free flowing in the ordinary sense of the term in which it's used in powder metallurgy, we'll say, where it's a very important property.

Well, maybe what you want to do -- it shall not be clumped. I mean this is what you're saying.

HENNIGAN: Right.

FLEISCHER: I would interepret this to mean that it can pass the Hall test within a reasonable flow.

HENNIGAN: But on the test, if it's usable, the girls can use it there. That's it.

COLSTON: This is similar to this next statement -- brownish red in color. We've been up to the -- we have seen cadmium oxide that they wanted to use that was gold. And we had never seen it before-- about the color of the fringe on the flag over here.

And we took it. We did a chemical analysis of it -- no different. It seemed to work in plates and what-not, but it's different. And the reason why we say things like free-flowing and specify a color is because we have seen different cases, but this is the way it normally is when we know it works. And if something comes in that's purple with gray spots, it may be great cadmium oxide, but we want them to have to call us up at least on the telephone and ask our permission before they use it.

HENNIGAN: Well, what we normally do in these cases is we'll have them make us a few cells and cycle them as many times as we can without holding them up too long. And this is a very small production with them. It's

rms 9

almost a nuisance to them, but we have to do these things.

FLEISCHER: Well, I was just calling attention to the term free-flowing in here which is not the normal use of the word, because cadmium oxide is simply not free-flowing. If you look at it, have electron photomicrographs made, which I had AS&R who supplies most of the cadmium oxide from their Denver plant, every particle in that thing has a cubic shape. It's sort of a remarkably uniform product, and it's very difficult to see why this stuff doesn't flow, but it doesn't.

And then the other thing I'll say is we were never able to match colors of the drums, but this didn't make any difference. Now, the reason for this is that the free cadmium content -- if you analyze cadmium oxide, the cadmium content is always greater than corresponds to CDO, the chemical composition CDO.

Once in a while you find some free metallic cadmium,but this is not really the source of the excess cadmium, it's the fact that it's an oxygen deficient material, so you just don't get the same composition in every grain, so you have differences in color. Well, if everybody understands what you mean, all right. But this is not the normal use of this term.

HALPERT: Ed, I'd like to ask a question about the term "electrical utilization." How is it determined

rms 10

here? And is this the proper place for it? Or should it be determined downstream further?

COLSTON: This spec is written such that in the front part of it you have what we want, the in product on each state. In the back of the speck is where according to the form we put the tests and what-not.

Now, I think this electrical utilization says in effect the tests will be done in accordance with standard manufacturer procedures, so what in effect it says is do it the way they usually do it. I do know that they make lot tests. They test each lot of silver as it comes in.

HALPERT: They make plates out of it first and determine whether it reaches this 2.6 grams per ampere hour. Is that it?

COLSTON: I don't know the exact test.

HENNIGAN: Yes, they make cells, 10-ampere-hour cells and test them.

COLSTON: Any more comments?

(No response.)

The particle size then we list .95 microns to not greater than 2.5. About a year and a half ago we had some trouble, and we did notice the particle size of the cadmium oxide used in the plates had changed. And the manufacturer of the cadmium oxide had changed, and so we put this in so that at least this is one more thing that

rms 11

was used when the cells acted like they should act. And there seems to be a problem in getting suppliers of cadmium oxide in this range.

HENNIGAN: I would like to comment on that. The only way we can get the cadmium oxide this way is the company that makes it, American Smelting and Refining, every once in a while they make a lot and they send a sample to Yardney, they check it. If it's within spec, they buy it. If not, they don't buy it. And they buy a lot for about a year. That's the only way we can get it now.

CHREITZBERG: How do you check particle size?

HENNIGAN: They use a Fischer instrument. On this type of thing it's up to the manufacturer to check it the way he normally does. And we know he has this instrument and he uses it.

CHREITZBERG: Do you feel the different labs can duplicate it with the same type of instrument?

HENNIGAN: I really wouldn't know. If you want to make a note of that, maybe we'll get to it later.

COLSTON: He does send us out data -- the manufacturer -- on his measurements of particle size.

Any further comments?

(No response.)

All right. On the cadmium oxide powder requirements, table II, Yardney tells us that the last item, the lead,

rms 12

should be changed to .01 percent maximum.

GROSS: Ed, which of these impurities have caused you the most trouble in the past? And which should be looked at most carefully?

COLSTON: I'd say the impurity that has caused us the most trouble is in the next section in the separator, the wetting agent. Of course, some things in here such as the iron and what-not you wouldn't want a great deal in your cell because they tend to poison it, but I don't think we've noticed anything.

Okay, Separator materials.

Under woven or non-woven nylon. Under thickness, the 3.0 plus or minus .1 mils under 3.2.4.1 (a) should be for a non-woven nylon 4 to 7 mils one type, and then the other type is 3 to 5 mils.

Under the woven nylon we are told it runs 2.2 to 2.8 mils in thickness. Now, the wet-out time, this is an item we have no standard for here, it shall be at least so many hours or not greater than so many hours. The manufacturer does measure this, and I would say the thing to watch out for would be if on these tests he got an unusually fast wet-out time. To me this would imply a wetting agent, something like this. I would question the separator lot.

Generally nylon does not wet very well. Organic

rms 13

extractables: This is a test -- we give a method in the back, things like wetting agents, lubricants shall not be greater than -- you can change that to two percent by weight.

Now, we've had it pointed out to us that the solvent mentioned can absorb water and possibly throw your measurements off, but the test in practice seems to work, and we've caught a lot that was suspicious, and we have passed other lots.

Then the next statement, "Wetting agents. The Separator material shall not contain any wetting agents." Now, the reason we have two different statements, in (c) we hope to catch a wetting agent and several other things. In (d) -- that was put in because our chemist told me that there are some wetting agents that a tenth of a percent would interfere with your cell operations. And so just to be on the safe side just say that no wetting agents will be allowed.

Okay. Are there any comments or questions or anything on this?

SULKES: Sulkes, Army Electronics Command.

I just want to jump back to the cadmium powder requirements. On your impurities, rather than affecting the cell electrical performance you do have I believe magnetic requirements, and do you feel that these particular impurities should be looked at for that reason rather than

rms 14

the electrical requirements, particularly things like nickel and iron?

COLSTON: Theoretically, yes, I think that on the nickel and iron that you would have to have a very significant amount, one percent probably and up, before it starts affecting the magnetic ability of the cells. And on that the cells we have ordered to these specs, by the way, are with no current flowing. As measured here, it's less than .2 gamma at 18 inches, which is just about the accuracy of our test range here.

HENNIGAN: This batter is essentially non-magnetic. Yardney can't check it. They don't have the instruments, so we have to check the cells when we get them. Now, if they're built according to this, we feel they'll be nonmagnetic and pass the test.

HALPERT: Ed, I'd like to ask, back in 3.2.3 where the chemical analysis is done, does the company specify to the AS&R these chemical analyses? Do they actually check it?

COLSTON: Let's see. The chemical analysis should be probably as it's bought.

HALPERT: That's made to the spec.

COLSTON: Yes.

HALPERT: How about in the separator materials, do they check these values, that is the battery company, or

rms 15

do they impose a restriction on the separator company?

COLSTON: They do check -- let's see, wet out time. This spec calls for them to perform a test for organic extractables. Wetting agents would be a sort of thing that would be put in there, order forms from the supplier.

COHN: Cohn, NASA Headquarters.

Coming back to this magnetic properties question, it seems to me I remember talking with the people from GE who deliberately add iron to the cadmium plate, and I don't remember what the actual percentage is, but I think it might go as high as 10 percent, and will reduce this to metallic iron. And yet apparently that passes the magnetic test here, so I imagine that what is governing here may well be the particle size rather than the amount of iron. It is well known that if the particle size is below a certain threshold size that the magnetic properties decrease drastically, and apparently what happens is that the iron is finely enough divided -- or cobalt for that matter, if it is present, or nickel -- that the magnetic properties are much less than you would expect of one big lump.

COLSTON: Any further comments?

BOGNER: Do you use the same separator material in the silver-cad as the ni-cad? And if you do, why wouldn't you havethe same spec?

rms 16

HENNIGAN: This is calendered material. These materials are calendered. The ni-cad materials arecalled maximum loft, what it means is calendered on a hot roll.

SCOTT: What about the other specifications though for resistivity, electrolyte retention, air permeability and the various kinds of things that were discussed the other day in connection with nickel cadmium cells?

COLSTON: These cells are flooded. WE assume that we have no gas recombination. We don't care if it takes a week, generally when we add electrolyte it wets very nicely in about 72 hours. If it took an extra day, we wouldn't mind. So, as far as allowing gas to pass easily through it and how quickly it will wet with a flooded cell such as this, it doesn't seem to matter.

HENNIGAN: Let me make a comment. There's one material we have used. You can use Pellon, the non-woven, or the woven. The woven nylon doesn't wet at all, and it works fine in the cell. I mean it won't wick(?), that's a term for notwetting.

CHREITZBERG: Chreitzberg, ASB.

I'd like to ask a question. In the thickness, especially in the dry thickness, can you specify the pressure in psi that is used by the measuring instrument. In paragraph 4 I believe you mention a Cady gage, is this one psi pressure? This is not critical for the woven

rms 17

materials, but it will affect the results tremendously for the non-woven materials.

HENNIGAN: It is probably a good point. We should specify the weight of these.

COLSTON: Further comments?

(No response.)

All right. Should we go on to silver treated cellophane?

Now, since this is the way Yardney manufactures the cells, we have it like this. But as to whether silver treated cellophane is an improvement over straight cellophane seems when you ask the manufacturer to depend on whether they use it in their product or not. But since Yardney has it in their product we have a specification on it.

We have dry thickness, moisture content, resistance. That resistance shouldn't .014 ohms per square inch. It should be .014 ohms inch square.

Then silver content. Wet thickness, we do have some results there. I don't know if you are familiar with a device developed by Mr. Hennigan here for measuring the swelling of a separator. Basically it is a rubber bladder sort of thing inside a frame. You put your separator in it. You have a caliper head against the side. You take a measurement, take a reading. Then you add electrolyte,

rms 18

allow the cellophane to swell. The bladder expands. Then take another reading with your caliper head, and you get your increase in your swelling of the separator.

Generally these separators triple their width roughly upon addition of KOH.

Visual inspection -- I think these are obvious. This is an inspection which is performed.

Any comments on this area? Dr. Fleischer?

FLEISCHER: C-19 is a proprietary material. And the only way you can get any idea of whether you can make it -- I mean we're talking suppose I want to make it -- I'd have to go to the patent.

And I'm positive from having read that patent that I wouldn't be able to make it. So, now what do we do. This is a general thing. We've specified something that is a secret for which there's no clearcut way of knowing how to make it. And you put that in here. This sort of negates the whole specification.

COLSTON: No. This specification, as I've said before, is written directly at Yardney. It can be modified for other suppliers. By the way, I have bought silver cadmium cells from other cell suppliers with the silver treated cellophane.

FLEISCHER: Well, there is another patent. That's why I brought it up. They use a sodium borohydride reduction.

rms 19

And it's spelled out quite clearly. Well, I think then you will have to put in a statement here that where it refers to a thing like that that you will accept a substitute which has been qualified.

COLSTON: If I was using this specification to order silver cadmium cells from another manufacturer, I would have to drop certain areas and rewrite them. Yes, definitely.

FREISHER: Well, I think under the circumstances I would say so in the specification.

RYDER: I agree with that, with Dr. Fleischer. I am very confused. Maybe I don't understand the intention of this. Is it to review a proprietary Yardney specification period? Is that the intention? Or is it to attempt, as Dr. Fleischer has indicated, to work out where compatible with your objectives a specification which will not be a Yardney specification but which will truly be a Goddard specification which might possibly be capable of being met by people other than a proprietary source. I think this goes to the key question of the whole discussion.

COLSTON: This document -- we do buy silver cadmium cells from many manufacturers for evaluation. At the present time, based on history, experience, characteristics, the only manufacturer we fly is Yardney. This may change in the future.

rms 20

On buying our evaluation cells for evaluation, to look at them, send them out to Crane to test them, we will change this. The intent of this document was to assemble all the various specification we use for having spacecraft quality flight cells, silver cadmium cells, manufactured for space flight use.

Now, this silver treated cellophane business is in here. It is the data and what-not from the Yardney type of process. We go to a manufacturer and we want to buy some silver cadmium cells and they don't use silver treated cellophane, we drop it. If they get it in there a different way, we'll look at some of our data. We'll put in some -- personally I'd leave the visual inspection in there. I still wouldn't like tears, fingerprints or scratches in it. But we would use this for their -- we would modify this for their process. But basically this is written for space flight use for space cells.

When we get two manufacturers or three manufacturers of this type of cell, yes, this will have to be modified.

FLEISCHER: I think you can get around the objection by taking out the words "C-19." You have silver treated cellophane(C-19). So, if you take out the word "C-19," then what you're telling me is if I build a battery with silver treated cellophane which meets this requirement, I can pass the test.

COLSTON: No, you can pass this section.

FLEISCHER: Yes, but I can't if you call it C-19.

COLSTON: Okay. All right. I think that's valid.

SEIGER: Seiger, Gulton Industries.

I think similar considerations would have to be given elsewhere, for instance, you spell out the cadmium oxide powder. There are other ways of making negative electrode You can start with cadmium hydroxide as well.

COLSTON: Further comments?

(No response.)

All right. The cell cases and covers.

We have a visual inspection and them some dimensions. The dimensions are not given, just the tolerances. The dimensions will be dependent on the case design and the cell size.

Comments?

READ: Read from General Electric.

Wouldn't some sort of a material definition be appropriate in there?

COLSTON: We have a statement to the effect of -- let's see what is it -- Bakalyte(?) or equivalent, C-11.

READ: Okay. Thank you.

COLSTON: Then we have an internal pressure test. We have the operator guess at what the burst pressure is. He applies half of this pressure for five minutes and looks

rms 22

for evidence of leaking or cracking, and then after the five-minute period he raises the pressure of the cell case until it does burst and records the data. Now, this, of course, cannot be performed 100 percent. This is a sample sort of thing.

Any questions or comments?

Grids. All grids shall be expanded metal number one mesh. Now, this is optional. This is a design criteria. I personally feel that you could improve the high rate characteristics of this cell by having a finer grid on the cadmium plate.

Usually, though, these cells come with a one grid or a one zero. Then we say we want it 99.9 percent pure silver.

Comments, questions?

(No response.)

All right. Miscellaneous components. And this is what has been described as a motherhood statement. Basically we don't want anything to be susceptible to KOH corrosion, and we also want everything to be non-magnetic. And here again to show that it is non-magnetic they would probably have to send samples here, and we'll run tests on them out at the magnetic test range.

Comments or questions?

FLEISCHER: I want to go back to the silver content.

rms 23

That's paragraph 3.2.6.2. There is a federal specification or a military spec, and I've forgotten which one. I think it's the military. It is for silver. Why not use it? I mean specify the silver to be something for which there has been written a government specification? I just don't remember the number right this moment, but there is one.

RICHARDSON: Richardson, Marshall.

What is the specific criteria for being non-magnetic. In your application do you require your batteries to be non-magnetic. Is this the reason?

COLSTON: Yes. This is one of the main reasons for using silver cadmium cells. you have a small scientific satellite such as built here at Goddard. They've got a magnetometer or something on board, an instrument that would be affected by the magnetic characteristics of the battery, so you build a non-magnetic battery.

RICHARDSON: If we were to consider using these maybe in a reusable space booster or something like this, this would not be a criteria which would affect us.

COLSTON: No

UCHIYAMA: Uchiyama, JPL.

Can I assume the statement of non-magnetic to mean really magnetic stability rather than non-magnetic?

HENNIGAN: These can't be permed(?) up. They put them in a rather strong field, and they still will not rms24

pick up any magnetic property. And they're stable in the earth orbit, going through the magnetic field and so forth.

COLSTON: And It's not absolutely non-magnetic either. What is meant is that we would like it to be such that we just can't measure it here.

There is another -- it hadn't occurred to me -- advantage of silver cadmium cells. They do have a relatively short life to nickel cadmium, generally on a typical IMP type mission we guarantee them a year, and they usually last two, given the correct orbit.

But we do generally fly at -- considering the total amount of watts in the battery, not the amount that is used -- we fly at a higher watt hours per pound than the typical nickel cadmium battery. I think RAE, for instance, flew, considering the total capacity, at about 8.7 watt hours per pound.

The IMP-I battery we've got over here will fly at about 13.8 watt hours per pound. This is considering the total watts in the battery, so we've got a gain of five watt hours per pound. Although in two years the IMP-I battery will be dead and the RAE will probably still be working. So, this is one other advantage.

GROSS: Gross, Boeing.

On dimensions I would think that the radius would be an important dimension to include. The sharp internal radiuses will help promote cracks and sharp outside corners make it difficult to install in packages.

COLSTON: There is a statement in here, isn't there, on the curvature of the edges.

HENNIGAN: Do you mean the case or the plate?

GROSS: The case.

COLSTON: Yes, if it is not in here, that's a good point.

REED: Reed from BAttelle.

One more question before we go on. In all the other specifications here for purity, you specify purity except for the silver powder. I do not see a purity requirement on the silver powder. Is that an omission, or is there a reason for doing this?

COLSTON: Let's say what do we say here? There is no specification on the silver powder.

HENNIGAN: I thought there was.

COLSTON: I would assume we imagine that it is pure silver powder. But we don't have a table in here.

HENNIGAN: Some of the information here is somewhat proprietary to Yardney, and we couldn't put it all in.

COLSTON: Sometimes extras are thrown in. Perhaps it would be a good idea to have a table in there and give a certain percentage to a magic ingredient and then list some possible impurties for the silver powder and this sort

rms 26

of thing. Althought the trouble we have had so far has not been with the composition of the silver plate. We've had trouble with the cadmium plate, but not with the silver.

CHREITZBERG: Chreitzberg, ASB.

Does this mean that the silver powder contains palladium or lead or some other additive?

(Laughter.)

COLSTON: Any further comments?

FLEISCHER: Both ____________________ and Englehart have standard specifications for purity of the silver. And they grade their various powders, and I'm sure you can get their analyses as to what their specifications are.

I know I have them somewhere, but I just don't carry that in my head, but you can get them from both.

HENNIGAN: I will answer your question, Gus, we have used cadmium oxide mixed in with the silver powder, which they claimed was for reversal protection, but I don't think it did that much, plus we balance the cells so well that we're pretty sure that we aren't going to reverse.

COLSTON: Yes, I think there should be something in there on the silver plate.

Oh, on the dimensions of the cell case, one thing that we as a user do usually, when we do start getting

rms 27

data on the cell, we add up the total thicknesses of the number of silver plates in it, the total thicknesses of the number of cadmium plates in it, add in all the various nylon separators, take the total thickness of all the layers of cellophane, multiply it by three -- that would be roughly its expanded thickness -- add up all these widths and make sure it's less than the internal width of the case.

We have had a problem with too much material in too narrow a case. This is a little check we do.

BOGNER: Do you have a draft on the case, or do you measure it at the narrowest spot or how?

COLSTON: These are the design dimensions of the case. We get this data.

BOGNER: I mean you have a draft angle on the case. It's not a perfectly symmetrical case?

COLSTON: Yes. It is probably what -- halfway down?

HENNIGAN: This is the average dimension at the center.

COLSTON: Which would be halfway down. We found out it's pretty difficult to make a case without a draft. We have one with minimum draft now.

FLEISCHER: The cases actually don't have much draft inside. I think for the size you're using here it would be about 1/1000th of an inch.

HENNIGAN: No, it is more than that. I would say it is around 7 or 8 thousandths. On a case about three and a half inches high.

FLEISCHER: Well, the Nike missile case doesn't have that much draft.

SULKES: These typical cases run about 8 mils per inch. If you get down to 2, you're doing pretty good.

HENNIGAN: We have been developing a case that has essentially no draft. Bob Steinhauer, what is the draft on those cases?

STEINHAUER: Two-tenths of a degree compared to a ______________ practice of about five-tenths to one degree per wall. This is about compatible with what Art Sulkes mentions. Is that mils per running inch?

SULKES: Yes.

RYDER: I asked if it was C-11.

SULKES: I said that it could be C-11. It could be ABS or other material of that type. It doesn't seem to matter too much.

CHREITZBERG: Would it not be well to specify the pressure and psi that you want to have exerted on the cell pack when it is in the jar. You get close to it in 3.2.4 where you specify the wet thickness of separator cellophane being four pounds per square inch. Isn't this

rms 29

really what you're trying to achieve by the summation of the thickness of all components?

COLSTON: There's very little pressure as such, because we're trying to get the total swollen thickness of everything after you add the electrolyte still to be less than the internal width of this cell case.

HENNIGAN: It's pretty hard to specify internal pressure here if you've got a taper and then you've got a U-fold that's bunching up in the bottom. Do you do this?

CHREITZBERG: We do not, but we find it is critical.

COLSTON: Comments?

VOICE: We better move along faster.

COLSTON: Okay. Flexible parts. Solder and fluxes. Terminals. Cements. This Plexiglas Cement is for if you have the manufacturer seal the header to the case. Pressure gages, if ordered on the cells. Then we come to subunit assembly.

Cadmium oxide mix. Then we have cadmium oxide, silver powder and PVA percentages. Here again, a different manufacturer that has a different recipe, these would be changed.

Electrode mix weight. And then we have percentages. Dimensions. Visual inspection. Then the electrode weighings. We have every plate weighed and recorded. And we are sent the data on every plate that goes into our cells.

rms 30

We are even sent the data on the rejects that didn't go into our cells.

And, by the way, this is another check. There's usually a -- for a typical process there's a certain percentage of rejects of cadmium plates, certain percentage of rejects of silver plates. The cadmium usually is almost twice the reject rate of the silver plate. But if the manufacturer is running along at a certian percentage rejects and you're getting the data. Then on another run the percentage rejects is up or down, say, five percent, personally, I would go and find out why.

SULKES: A comment. The silver powder that you call out in the negative electrode is that required to meet the same requirements as the positive electrode powder? And is it intended to be the same powder?

COLSTON: I am not sure.

HENNIGAN: We are not sure about that.

SULKES: Actually, is there any requirement on it at all?

COLSTON: All I can say is it is a good point.

FLEISCHER: How does silver powder provide overcharge protection?

COLSTON: We don't overcharge these cells. We don't even fully charge these cells.

FLEISCHER: Didn't you make a statement that that's rs 31

why it was added?

HENNIGAN: At one time we used to put cadmium oxide into the silver electrode. There was a claim and there is a patent that this will provide overcharge protection. We really never thought it worked that way.

FLEISCHER: So this silver powder is --

HENNIGAN: That's for conductance.

HALPERT: Can I make one comment? Yesterday we talked a lot about traceability and making sure we do have traceability and also statistical methods to make sure that in sampling we have the proper mats(?). And none of that is mentioned in here. I just would make the general comment that maybe in the consideration of changes you might want to use the Mil specs in terms of sampling and also make some statements with regard to traceability of the basic materials, namely PVA, the powder, the silvers, everything that's used.

COLSTON: We do have a statement in the beginning on the standards we call on NPC-200-3 which does have I believe traceability requirements in it.

GREEN: Green, Martin.

I was interested in a statement you just made that if a particular order should run greater than, say, the average percent rejects you saw in the past or less than the percent rejects, on what basis would you highly question

rms 32

less rejects?

COLSTON: Either way. I would say that something had changed. It is entirely possible it could be for the better, but I'd like to know what it was.

NIETZEL: Do you have an internal specification on what rejection rate would then reject the whole lot?

COLSTON: No, we don't. See, this is not a sample basis where you can say if on our sampling of ten percent we'll reject the whole lot. This is an individual basis.

NIETZEL: A sorting operation.

COLSTON: Yes, and we're getting data on the accepted plates and the rejects.

Are there further comments or questions?

(No response.)

Let's see, then we have requirements for the negative electrode dimensions. We threw in here to make sure that this manufacturer uses half plates on he ends of the plate stack, that we had an understanding that he would color code the lead in wires so that we could visually look at the cell and say yes there are half plates on the end, and he didn't slip any into the middle of the stack. But we got one order on which it wasn't true, so now we've got to the fact that it shall be color coded.

On the positive electrodes, here again, we've got

rms 33

dimensions. And if you will notice on all of these the thicknesses of the plates, or the tightest(?) dimension. And then we say basically that we will get data on the weight. We've got lead forging.

There was a comment that Yardney wants the thickness of the plate and lead at the welded joint -- can exceed the plate thickness by not more than .004 inches maximum.

Adhesion. Visual inspection. Then a general visual inspection of the plate itself. And within the past year or so, we've seen another type of defect that should be put into this visual inspection that the silver plate shall be free of greasy fingerprints.

Then the rolled silver strip sort of specification. Now, this can be modified to accommodate other procedures for making the silver plate. Then we have the separator system describing the wrapping system, and it asks for five wraps of the separator. And personally -- this is my opinion I agree with this, there seems to be some sort of -- one 2-mil thick cellophane separator does not seem to stop silver as well as two 1-mil thick separators right together. There seems to be something associated with the boundary or something. So, this is why I do agree with the five wraps.

Any comments?

rms 34

(No response.)

On the unit assembly, cover assembly, they have visual inspections, terminal dimensions. Some of these say basically in accordance with the contract. Cell assembly. It describes the wrapping procedure listed previously. We don't want excessive bends in the leads and tabs.

Terminal soldering, describing run-over and the amount or how much they can play around with the cell plates aligning the lead-in wires into the barrel terminal.

Terminals shall be free of potting. The terminal barrel tubes shall be wiped clean. It was noted that you get an orange peel effect on top of the solder if you don't wipe the barrel clean. And when you do, you don't get it. Now whether this makes any difference I don't know, but I like to see a very nice solder job, solder with a clean surface, so this is why that article is in there.

Soldering heat shall not discolor the terminal, which in some silver cadmium cells they put way too much heat to it, and they do burn the gold plating slightly which is on the terminal.

Do you have a comment.

GROSS: Yes.

Ed, these specs suggest that the manufacturer can choose either woven or non-woven nylon. Do you have a

rms 35

preference? I would suggest that the buyer select either woven or non-woven nylon. They both seem to work as well, and there seems to be a smaller chance of getting your wetting agent with a woven nylon. So, personally I would get woven nylon.

GROSS: So you are using woven mostly?

COLSTON: Other comments?

(No response.)

Terminal potting. This I do think is important to have a lot of inspection on how the -- in this case the bond master is applied to the wires to keep the electrolyte away from the solder, to cover voids. It's a girl there that's doing it, but you want to make sure that she is doing it. I have seen cells -- I've been to the plant and seen our spacecraft cells being made here and right next to it was a lot for another area, same type of cells, but yet just by looking at them, looking at how the potting was done, the quality of the plates, there is a difference. And it is important that you have this sort of visual inspection. And on this terminal potting we just had a case of where they've got the battery on the spacecraft, and it's upside down.

And if there are voids and holes in that what we call blue goo(?) potting, bondmaster, that electrolyte is going to be at the goldplating. And if there is a void in

rms 36

that, it is going to get at the brass, so there may be trouble.

STEINHAUER: You said a single potting procedure, or do you use a sequential operation, ultiple potting?

COLSTON: It is sequential. They put the plates in the cell cases with the wires sticking up, then the girl comes along and arranges them and bends them, fits the header on. They go through the whole lot. Then they come along and cut off the wires. Then they put the solder on. Then they come by with the bondmaster and apply it to each one. Then they go back through the lot and look for voids and visual inspection, this sort of thing, and touch-up.

STEINHAUER: There's not a second layer of bondmaster that goes over? It's a single pot?

COLSTON: I've only seen one layer.

RICHARDSON: Is this the only technique in making terminals for a silver cadmium cell? Could you use a comb technique like in the ni-cads? A mechanical seal joint or something?

COLSTON: Yes.

RICHARDSON: But this is the particular technique that Yardney uses, is that what you're saying?

COLSTON: This is the way they do it. There are other potting methods in the way you arrange the wires.

rms 37

And there is a comb. I have seen a comb on it.

RICHARDSON: These are non-vented cells; is that correct?

COLSTON: These are completely sealed cells in operation.

RICHARDSON: What type of material pressures are generated? Have you observed?

COLSTON: If it is a plastic case, you can't stand much pressure. Generally on the tests I've seen with the pressure gages and what-not we operate in a partial vacuum.

RICHARDSON: Most of the time?

COLSTON: Yes. We run it so that you get the gassing, say, in the last 10 percent of charge. These cells are nice in that the voltage rises toward the last part of charge. So, we can set a voltage limit, stop the cell before it is completely charged. We generally charge up to say about 150, 151 volts per cell. When it reaches that limit, the current tapers down to a level of about 100 milliamps, then we go to open circuit voltage, in which in effect no current is taken from the cell or given to the cell.

RICHARDSON: For a general spec you might want to consider modifying that area on the terminals fabrication and sealing technique.

COLSTON: Yes, for a different manufacturer they

rms 38

would probably have a different terminal design.

READ: Read from General Electric.

I think this potting is a fairly critical area that perhaps might deserve more attention as to mentioning the materials that you actually use and the mixes that you use and this type of thing.

COLSTON: You mean within the cell around the lead-in wires?

READ: Yes, right here. This paragraph 3.4.2.5 it seems pretty general. This was the area that I thought perhaps could be strengthened by material specifications and mixes.

COLSTON: It is a bondmaster mixture that they use, but it is not mentioned here.

Questions? Comments?

(No response.)

All right. Internal resistance measurement. We have a diagram for that on the back. This is to check for gross shorts.

Assembled cell dimensions and cell weight. And we also reweigh the cells when they come into Goddard.

SCOTT: Is there any point in leak testing? If so, I don't see any provisions or specs for leakage.

COLSTON: These cells, as delivered to Goddard, the header has a hole in it that's not sealed. And the header is not sealed to the case. And there's no electrolyte in the case.

HENNIGAN: There is a hundred percent leak check of the terminals.

SCOTT: All right. So, I guess the point is that this is strictly for use by the cell vendor when the cells are purchased in the dry condition.

COLSTON: Yes.

SCOTT: You have some internal leak limits then that you work to for your own final -- before you put the thing into the spacecraft?

COLSTON: Yes, he puts it in water.

HENNIGAN: We check them underwater, but don't forget that these cells are potted also.

COLSTON: After we assemble the battery, within the battery case there is a layer of potting.

HENNIGAN: There's no helium leak check. Let me put it that way.

GROSS: Gross, Boeing.

The cell specification then carries the process up to the point of putting the ingredients in the cell but not sealing it and adding electrolyte. Would it not also be useful to add to the specification the steps from then on that are done at Goddard, even though the specification is not required by the manufacturer, these are steps

rms 40

that you do that would be quite useful to be included in the spec.

COLSTON: Personally I don't want it included, but we have agreed on the need for coming out with a document, although we've given people handouts and what-not -- coming out with a document describing what happens between the time these cells arrive at Goddard and we assemble the spacecraft battery from them. But personally I don't think they should be in the specs. That is a process that we do like to do ourselves.

RICHARDSON: Richardson, Marshall.

With the one hole -- do you know if the vendor runs a pressure check on the cell after he has put his cell cover on and sealed it? You know, you have the one hole available. Do you know if he just runs a pressure check on a cell to check out the seal. In other words, run maybe five or six pounds and watch for the pressure drop-off to check for leakage.

COLSTON: This would be on other people's batteries, or cells.

HENNIGAN: He will do that. That can be done.

RICHARDSON: Are they doing it on your cells?

HENNIGAN: They can't because these cells are not sealed. The cover is not sealed to the case.

RICHARDSON: Okay. Then do you do it here at

rms 41

Goddard after you seal the cover?

COLSTON: No, generally not.

HENNIGAN: We just check them underwater to see if we see any bubbles coming up. But these cells are potted and totally encapsulated.

RICHARDSON: Yes, I realize that. We have had some silver zincs that have leaked even though they were potted, so just because the top is potted -- in other words, you can get KOH and you run into a shorting problem, if the KOH leaks out on top of the cell. You can get shorts to the case. Shorts to terminals, and so on and so forth.

COLSTON: These cells are potted all the way around, and visual inspection is possible.

FLEISCHER: I will make one comment. I think testing of these cells should be very easy. For example, every Edison cell that was ever made -- and they were not sealed cells, they were vented cells -- was put underwater and tested at 50 pounds air pressure underwater to make sure that all the welds were sealed and that there was no leak in the cans.

So, it's very simple to do this, and it should be done.

GREEN: (Martin, Denver.) Just a quickie before the break.

I am listening here to this specification, and it

rms 42

appears to me under your statement that you did not want to include Marshall's processes, that if a contract should come out and the decision by the project office should be that the contractor shall buy and procure and furnish a battery with the unit that then he would not have a specification uniform as we're striving for unless he wrote it such that it would satisfy the requirements of Marshall for the consistency thereafter.

And if the purpose of this is to develop a uniform specification to assure quality products, we would have to have this other information so that we could buy a completed battery from a vendor. Is this not true?

COLSTON: Yes.

Let's take a break here.

(Recess.)

COLSTON: Okay, I'm told that we have to go a little bit faster. One comment I'd like to put in here. One reason why we get them dry -- when we get them dry, we can form them and fill them -- fill them and form them ourselves, take all the time, do triple inspection, do it very carefully and precisely. And also we've found that in getting them dry we can store them for up to five years and then fly with them, have a flight battery.

If we got them already formed and sealed and everything else, we'd probably have about a six to eight month

rms 43

limit about when we'd have to assemble a flight battery.

All right. We were on what -- cell assembly, 3.4.2.

Then it gives a visual inspection procedure to make sure that they assemble the cell as per specifications. We have a maximum limit on the leads and tabs that the bin shall not exceed 75 degrees.

Terminal soldering. You have terminal potting. We've been through this. Polarity marking. Internal resistance. Cell weight.

Then responsibility for inspection. We use the supplier's QC people plus the D/CAS man, plus we have been to the plant during manufacture and talked with them and inspected them ourselves.

Then on the components, for the KOH we say basically that the stock solution be inspected in accordance to the manufacturer's procedures. We do like the components to be marked such that they can be identified for NASA Goddard or for space flight use. And so that they're traceable.

On the electrolyte then, we have mixing. We have sampling in which he does do the chemical analysis. Then we have a paragraph labelled marking. Here again we try to get it identified for NASA Goddard contract number for space flight use to try to keep these components separate

rms 44

from the general production silver cadmium cells. Then filling, bottle storage, packaging. And then we have silver powder. Now, here's your paragraph on electrical utilization. One plate from each of five cells in a production lot shall be tested at a charge rate of C/20 in a 40 percent KOH electrolyte.

Then basically on acceptance tests it says do it the way they've been doing it but send us the results. And then more data on marking, on the silver powder containers.

And on the cadmium oxide powder, the same sort of marking, acceptance tests and sampling.

On the separator material we asked that the manufacturer send us samples of the separator he proposes to use in the cell. And we also asked that he perform the wet-out test and send us the results.

Then we have an organic extractable test using a methanol solvent. For the silver treated cellophane -- this would be for any cellophane -- send us samples.

SULKES: I have a question.

In regard to your bottles, you have the electrolyte put into individual bottles for each cell; is that correct?

COLSTON: No, we usually get it in quart bottles, in polyethylene quart bottles.

rms 45

SULKES: I was looking under your bottle filling in 4.2.1.2, and it seemed to appear to be individual bottles. It doesn't matter then.

COLSTON: Further questions?

RICHARDSON: A comment. On that tab bending of 75 degrees, can you clarify that a little bit?

COLSTON: We don't want the plates, the wires, or the tabs to be bent excessively. The idea is perhaps under vibration they couls snap, this sort of thing. We like to see nice, uniform curves. We don't want to see edges where it has been bent too much and then straightened out.

RICHARDSON: I was just wondering if 75 degrees is a good criteria. You're talking about the assembled cell; is that right, the tabs after you put the plates back in the cell jar? Right?

COLSTON: Right.

RICHARDSON: How do you measure it? Do you just eyeball it?

COLSTON: Right. If you see something that looks bad, then you would pull the plate stack out. Remember these are not sealed. You could measure it.

Then for the wet thickness of the cellophane we call for 20 samples. And then the 24-hour soak and the thickness measuring device which I've described previously. Then we ask forthe data from this measurement.

rms 46

Any more comments on marking? Storage. We like to see a humid atmosphere for the cellophane. If it gets too dry it tends to get brittle and hard to work with. It cracks and this sort of thing.

Then there are a few statements on care of the humidor-type boxes that they store it in.

Cell cases and covers. On the opposite page you'll see a picture of the case rupture test fixture. Here again the cases should be from the same lot.

Then next on the moldingwe ask for Bakelite C-11. Here in this place it doesn't say "or equivalent," it should.

If machining is required, cases in covers will be annealed. It calls for rejecting on sandblasting. We like the headers sandblasted before they put the terminals on them because it is easier for us. We get the cells in, then when we are ready to use them we sandblast the rest of the case.

Demensions and internal pressures. Internal pressure test is a repeat of what we've given previously. It calls for 100 percent inspection, Storage. Grids. And then a catch-all statement on miscellaneous components.

Then on subunit assembly. The negative electrode. We call for a test every 50th weld. Basically what we're calling for is to hold the plate and pull the lead, and the

rms 47

lead should not come off without tearing the grid. There should be pieces of grid sticking to the lead when you pull it. This is destructive.

In the next paragraph on mixing it calls for EXMET. This could be "or equivalent." It describes how this particular type of cadmium oxide plate is made. The next paragraph calls for labelling of the cadmium oxide mix number. Then they call for a check on the proper electrode dimensions, waviness, flattness, cleanliness of the molds, and some more dimensions that are pertinent to this type of process. And it calls for where the five readings per plate shall be taken. Readings shall be made at three decimal places. And basically we ask them to send us the data.

Electrode weighing. We weigh to the nearest hundredth gram. And it shall include the leads. And they shall send us the result and include the data for the rejects.

Serialization. We like to have nice traceable numbers on every cell we get.

Storage. Sometimes in a dusty plant it is very useful since these cells are open to have plastic covering and what-not over the cell.

On the positive electrodes we call for readings, where they are to be taken, then send us the data.

rms 48

SULKES: I have a comment. In your negative electrode mixing and actually placing into the mold, do you intend this to be a center grid, or a grid really coming out on one side? This would seem to indicate that they dump it all in and put the grid on top, or the grid is in first. Whereas, I think you would like to have the grid right in the middle.

COLSTON: The end process produces a grid that's roughly in the middle.

SULKES: You don't require that half the mix be put in first and so on?

COLSTON: I've seen them -- let's see, on the process they put a little cadmium oxide down and then put the grid and finish it?

HENNIGAN: Right.

COLSTON: So they do do this. Any further questions or comments?

(No response.)

All right. On the positive electroe, the silver plates, again we call for weighings and data, the data to be sent to us.

Lead forging. Here again, five welded plates shall be tested for lead adhesion. You try to pull the lead off and the grid should come with it.

Serialization. Each electrode has a number.

rms 49

Storage. Then there is a section on the rolled silver strip.

Now, this would be modified depending on the procedure you use to produce the silver electrodes for other manufacturers.

All right. On the unit assembly, then cell assembly, they say care shall be taken not to lose the identify of the negative and the positive electrodes. And then they call for recording the numbers of the electrodes used in each cell.

Leads and tabs. Terminal soldering. Cover installation. Terminal potting. We've been through these previously.

Polarity marking. Internal resistance. And on the next page you see the diagram for the internal resistance set up.

Then we have a formula where the operator can plug in the data.

Assembled cell dimensions. The cell weight (dry). And Marking. Here again, we like the cells to be very nicely and legibly numbered with the date of manufacture, a serial number, this sort of thing.

Packaging. Well, we don't want metal bands attaching these groups together, because the bands can cut through. We do not -- this has been a problem because they

rms 50

like to do this evidently -- lubricate the terminals. We don't want them lubricated because we just have to turn around and try to get the lubricant off.

Then the next paragraph calls for Vermiculite. Now we have been shipped cells in boxes where thev have all the loose VErmiculite, and that stuff makes a very nice dust. And on open cells it likes to get into the cell. I really don't know whether this affects the cell's performance, and I just don't want to have to be put in the position of having to find out.

Then we ask for accompanying these that they send us this data. And then marking, mil standard. In the past the letters for space flight use were not as obvious as they should be. They were put on with a magic marker. And then we have ordering data.

Now, personally we like to use these, the following dimensions and requirements. We like to know them and we like to know the cell design to this extent before we order. And we like to specify it.

Whether you do it when you order silver cadmium cells, if you order them, that's up to you. Then the supplier-- this is where it says basically that this spec is written for Yardney. Perhaps it doesn't say it strongly enough. Then there are some definitions.

In the back here we have these test forms that we

rms 51

get our data on. WE get the dry and wet thickness, the rupture test data, the weight, size and thickness of the plates and the rejects. That concludes that particular specification.

Any questions, comments anecdotes, philosophy?

SULKES: Just one point, looking sort of ahead at your silver spec, you in the sil-cad spec allow a plus or minus 3.4 percent. In the silverplate spec for, let's say, zinc cells you're running it looks like about 2.8 percent. And it would appear if you could get it in that spec, it should be possible to achieve it here without any trouble.

So, this might be a little tightening up that you can do, or a loosening up the other one, depending on what's actually possible.

COLSTON: Yes.

PYDER: Ryder, Gulton Industries.

Did I understand you to say before that IMP was the program for which you developed this? Is this the only program on which you're using these cells.

COLSTON: These cells built in this manner have been used and flown on, let's see, seven IMPS dating back to 1962. We are presently building the batteries for IMP-I and later for IMP-H and J, also a silver cadmium battery f6r S cubed(?). We've looked at silver cadmium for PE, which is put off right now. And we have worked with

rms 52

the Belgians, the French and the Germans on silver cadmium batteries that they use.

RYDER: Thank you.

COLSTON: But basically at the present time there just doesn't seem to be that much business in silver cadmium cells.

BOGNER: I was wondering if it would be wise if you go out to other manufacturers if they would be interested in environmental requirements? Vibration, shock, thermal.

COLSTON: We perform, of course, vibration, shock and this sort of test here with the flight cells that we're going to use. We perform it on the battery.

RICHARDSON: What type of vibrational levels do you qual these things to? What maximum "G" levels? What frequency?

COLSTON: Do you remember?

HENNIGAN: I don't remember it offhand. It varies from shot to shot, but it is tied into the Thor-Delta.

RICHARDSON: Tied into what?

HENNIGAN: The Thor-Delta rocket.

RICHARDSON: You don't know if it's 10 G's? Five? Can you give me a ballpark?

HENNIGAN: I believe it is nine.

RICHARDSON: What frequency range?

HENNIGAN: A couple thousand, does that sound right?

rms 53

COLSTON: I would have to go back to the office and get the actual data.

RICHARDSON: Okay.

COLSTON: It is dependent on what your launch vehicle is, of course.

GREEN: Green, Martin.

Apparently you've had a lot of test experience with these batteries. Can you just roughly give me their performance comparison on high temperature and so forth, are they better than the nickel cad or are they a worse factor?

COLSTON: These batteries on the IMP program, I like to run them at roughly zero to 30°C. My most favorite range is 10 to 20°C. At above this temperature they tend to die quickly, and they operate nicely until they die though.

Below this temperature sometimes your charging regime, the voltage goes so high that you have trouble recharging it. And on discharge, say below 0°C sometimes you hit it with a, say a C/2 discharge rate or even almost a C rate discharge, your voltage drops initially so quickly that the undervoltage cutoff on a satellite system cuts off your battery. So, ideally I like to operate these things at zero to 30° C.

GREEN: How much shortening of life do you figure you might get at 30°C operation, just an estimate?

COLSTON: Mr. Hennigan says that 40° is less than a year and 50° is two months. And in the temperature range that I specified we tell the project managers we'll guarantee a year and it generally lasts two.

GREEN: Thank you.

FLEISCHER: I just want to be sure you carry out the environmental test, the shock test, on assembled batteries after they have all been formed, the cells have been formed and assembled. You don't do it on the cells themselves.

COLSTON: No. We might. If we had a problem we could take a couple of cells and walk over to the test area and have it done.

UCHIYAMA: Uchiyama, JPL.

I understand that these cells are flooded, vented?

COLSTON: No, not vented -- sealed.

UCHIYAMA: That's my question here. Just how do you go about assuring yourself of the seal, once you've activated the things, and do you have any requirements placed on the vendor relative to the subsequent seal that you people put on it?

COLSTON: None that is not in this spec. If they came up with something, some sort of defect that showed up later, and we thought that they did it, we could go back and

rms 55

have a heart-to-heart talk with them. But we usually don't have any trouble with the sealing on these batteries in orbit. See, we usually have at least one or two, perhaps three back-up batteries for each launch.

On launch we start testing the back-up batteries too. And we don't have problems with leaking.

RYDER: Ryder, Gulton.

You talk about like less than one year life and 2 months or 2 years. Is this low orbit, and about what depth of discharge are you talking about. In other words, how many cycles are we talking about and what depth.

COLSTON: Okay. Typical IMP is a series that looks at the magnetosphere of the earth and the solar winds and the shock wave of the earth. The orbits range from a low point of say about 150 miles out to about 280,000 miles. Some of them have a highly eccentric around the earth and go out beyond the moon.

IMP-E was anchored around the moon. The S cubed(?) will be an equatorial launch I think. Now, these things, usually the time of the orbit goes the minimum which so far has been eight hours. And it goes up to four days. We usually have up to about a 30 minute discharge, sometimes a 30 minute discharge continuously. We usually design these things for a 20-25 percent depth of discharge. We like to have about 6 hours to recharge them

rms 56

althought we're working with the people on the German satellite, and they have a two-hour orbit. They are discharging for up to 25 minutes and recharging, a different recharge regime than our two-step voltage regulator. They are recharging in a hour and 35 minutes. The current rate of these cells is usually low. Say for a 10-ampere-hour cell the current rate is around 2 amps. On IMP-I it will be higher. It will be almost 7 amps. And we'd like to see about 10 to 20° Centigrade of environmental temperature.

UCHIYAMA: This question is kind of directed at Tom rather than to you. At one of the ECS meetings you mentioned the effect of radiation on the separator material. Do these specs now take that into consideration or were these specs generated before you had those problems with the separators?

HENNIGAN: The only tests we've done here on the radiation of sil-cad cells is cobalt source, and that was 10^7 rads. That was quite a heavy dose. Now the reason we did that is at one time we did have a battery failure and didn't quite understand it. And they were going into the belts more than they should have because of the orbit they got. And we checked it out, but of course the cellophane goes. There's not much you can do about it.

We finally found out that was not the source of the failure. It was we felt a problem of quality control.

rms 57

RICHARDSON: What's the most significant failure mode you found in the silver cad cells, assuming you operate them in the range of zero to 30°C normaly operating temperature. What failure modes have you found.

COLSTON: They short out. The separator deteriorates. The silver gets all in the separator.

RICHARDSON: AFter long cycling necessarily or short cycling.

COLSTON: After long life, heavy strain, with age. We've had a few failure modes of explosion where too much electrolyte was added. This was way back when. There have been a few other instances, but they just wear out.

This brings up one point. I'm sure that these specifications can be tightened so that we can get much better cases, headers, seals, potting, terminals -- the terminal can be redesigned and improved. But at the present time there's no point in it.

The basic system itself, the cadmium plate, a silver plate and cellophane in between lasts one to two years. And there's no point in having a 5-year terminal until someone improves the cellophane and probably the plates.

COHN: Cohn, NASA Headquarters.

The obvious answer to that is to look into the separators that were developed for sterilizable batteries where you potentially have much longer-lived separators, so that you might up-grade the whole system and expect longer life out of it.

COLSTON: We investigated this and -- what is it, the RAI separator --

HENNIGAN: We'll have to get some of the Borden separators and RAI -- there's a problem there with uniforming of separators. Can we get the same thing twice. The cells would not work. Very poor cycle life.

There is one thing that we have looked at and it looks promising. It is a calcum hydroxide coating which in a 50 cycle test restricted the silver migration one-tenth of what it was in a control cell without the coating, but it's been a little hard for us to get somebody to really control that coating for us. We have somebody now thatwill do it. And once we can get some cells made and cycle them, we'll have a bit more information.

STEMMLE: A comment here. It might be misleading to say you restricted at one-tenth. What you did was you reduced it to one-tenth of what it was previously.

HENNIGAN: Right.

STEINHAUER? Comment Steinhauer, Hughes.

Considering what you know now on the silver cad secondary system, how would you -- if you were starting today, would you go silver cad, or would you consider silver zinc?

COLSTON: I'd still go silver cad on this use.

STEINHAUER: Why?

COLSTON: Well, these cells -- we don't get the watt hours per pound with silver zinc, but we are much better than nickel cad. The cells are very efficient in ampere hour current. We can charge up a battery and put it on the shelf for three months and then discharge it and get within 5 percent of what we put in it, so we're not sure if we actually put it in to begin with. So there's almost no self-discharge.

While it is sitting on the shelf the electrodes are not gassing like your silver zinc. These things operate in a partial vacuum, you know, inside the cell you don't have a gassing problem. It doesn't seem to have a real high rate that a silver zinc can do, but it's high enough and it has a longer life than a silver zinc.

And it's a nicer system, especially because of the gassing problem.

BOGNER: I think you have to qualify that when you say longer life. You may say cycle life, but total life, if cycles aren't important, will be nearly the same I think because you have the same failure mode usually, the silver penetration of the separator.

rms 60

COLSTON: Your zinc though likes to dissolve very readily too. Doesn't it?

BOGNER: Yes, you get some zinc, but a lot of cells I've seen haven't been due to zinc penetration.

STEMMLE: The zinc electrode actually is a bad actor. It sloughs off and you get active material in the bottom of the case.

BOGNER: You do get dendrite growth and sloughing off. But this does not affect the total life. Stand life. Shelf life. And it doesn't slough off when it is standing on the shelf, so what I'm saying is you've got to qualify it when you say life.

If you're talking about cycling it, over a short period of time you can get many more cycles usually out of the silver cad and the silver zinc. But if you only need 10 cycles over two years,maybe you can get it with a silver zinc.

PALANDATI: Palandati, Goddard.

In regards to the silver zinc systems that we have flown here at Goddard -- and these were Yardney silver zinc systems -- in regard to the cycle life, it was definitely nowhere near what you'd get on the silver cad cells and on your wet stand capability as such.

The wet stand I would say was questionable over 18 months. And these were the Yardney silver zinc cells

rms 61

using the same U-fold(?) configuration with the same cellophane separator system and the number of wraps. It was definitely nowhere near as good as the silver cad cell even in wet staying(?) capability.

COLSTON: Are there any further questions on the silver cadmium system, if not, I think this is leading beautifully into the silver zinc?

HENNIGAN: One more comment on the sil-cad cell. We have finally with special loving care got these cells to stay together, if they're made together. And they do take these batteries down to full depth of discharge several times during the year. And we don't get any luxury like cell sensing, so we have to sense the battery. And we find if the cells are made according to spec, formed in a special way and selected, we can take these batteries down to 9/10th of a volt without reversal.

My experience with silver zinc -- I don't think -- we haven't as much experience, but that's very difficult to do. They imbalance quite badly during cycling.

COLSTON: Yes, on a good lot on charge and discharge, these voltages stay together very nicely.

Well, shall we get to the silver zinc, Tom.

HENNIGAN: I'd like to go briefly through these two kind of first cut at specs on silver zinc and silver oxide plates. These specs were actually a cooperative effort

rms 62

between Goddard, Hughes Aircraft and ESB. We'll take the silver spec first. These were designed for approximately a 12-ampere-hour cell.

We have the usual applicable documents in the front here, and our NASA Goddard drawing number. It's not on here, but it's just a dimensional -- I'm sorry, yes, the drawing is attached.

Okay, does anybody want any of these specs on the silver plate or zinc oxide?

These are requirements here in ampere hours nominal capacity of the silver plate. The design goal of this battery was for synchronous orbit, asking for as a goal three years. We have obtained as much as one and three-quarter years to day in the synchronous orbits with silver zinc batteries at room temperature.

The depty of discharge at the peaks on the ones we ran was 40 percent of the rated capacity. This we felt -- we got a little bit higher to 60 percent. So, the charge time would actually be 23 hours, but using a two-step regulator you find at room temperature the battery charges up in about 13 hours. Then we cut it back so the charger is charging the battery -- if you want to use that term -- at open circuit voltage.

The physical requirements are given and the plate weights. Now, again these were all 100 percent inspection to determine if the manufacturer could stay within these limits.

COHN: What's a DP?

CHREITZBERG: Dispersed plastic.

HENNIGAN: Dispersed plastic, right.

As you see here, we do have some values to reject outside of -- on the grids. It's pretty hard to specify that grid weight, the way I understand it. And the only way to do it is buy a ___________ lot, and reject outside these limits.

The term "biscuit" used here is a term used as the silver electrode with the grid in it. Is that right, Gus?

CHREITZBERG: Yes.

HENNIGAN: That's a rather large sheet which we cut six plates out of?

CHREITZBERG: Yes.

HENNIGAN: Now, these buscuits were also lot grouped within the values that are shown here, the X plus or minus five percent.

Here, as I say, this is a first cut at this thing. Not all tests are specified. The ribbon is spot welded to the plate and inspected for integrity. We did have a spec on the plate density of the silver electrode.

Also there are some specifications here on the

rms 64

plate, electrical connection and the material to be used for it. Again, we're using EXMET materials as a grid.

The silver powder is specified as 99.9 percent. And with no other impurities exceeding 500 parts per million.

The grid is also specified in the sil cad one, we're also requesting here that the impurities be no greater than 500 parts per million.

STEINHAUER: Steinhauer, Hughes.

These levels of impurities were picked, as Dr. Fleischer suggested, from some of the major precious metals suppliers' specifications. It's not the entire spec, but those are the levels that you would normally expect there.

FLEISCHER: I think the government spec for this grade of silver has much lower impurity content.

STEINHAUER: For individual components I think -- I'm not familiar with the government spec on it. I was looking at the manufacturer's specs, such as Engelhard and so forth.

HENNIGAN: The capacity of the plates is defined in ampere hours. And the current densities at which the plates should be operated are given here, how to charge it and so forth.

SULKES: Is there any reason why that capacity

rms 65

is so low? I notice you're allowing roughly 4.2 grams per ampere hour in this particular plate as opposed to two six in the sil-cad.

HENNIGAN: Well, I think Ed mentioned before, we felt that 2.6 number is wrong, way too low.

SULKES: You mean it's too efficient, too hard to meet it?

HENNIGAN: Too easy.

SULKES: Well on this one you are allowing four two, which is about twice as high. In other words, you need twice as much material to do the job in this one.

HENNIGAN: Was it grams per ampere hour?

SULKES: Grams per ampere hour, right.

And this one works out you've got an 8 gram __________ for silver material and you're only asking for 2.1 ampere hours. That's roughly 4.2 grams per ampere hour as opposed to the sil cad where you're asking for 2.6 grams per ampere hour. You can't do much better than about two five roughly.

HENNIGAN: Did you have anything to say about that, Gus?

CHREITZBERG: If you take the positive plates and discharge them in excess electrolyte, they should do 2.6. If you perform the test on the cell, specify the cell pack and run it at the C rate, then you would be at the

rms 66

limit that's now specified. You wouldn't be lower than that limit.

SULKES: This actually though is running against a dummy plate, so therefore I would think you would want a much higher performance level.

CHREITZBERG: The test that we normally perform is run not against dummy plates, but in a cell with a separator system similar to what will be used in the ultimate cell. And we would like to have the spec at the same rate as it will be flown. And then the limits will be meaningful. I think this limit is too low, in answer to your original question.

HENNIGAN: The current density of the plates to be used is given in the next paragraph. It mentions in paragraph 3.4 that the hundred percent sampling is done on plate thickness, height and width. Grid weight for the six-plate assembly, that's the grid that goes into this biscuit, and the sintered plate blank weight.

We also requested that the individual plate identifications be maintained as we do in the sil-cad area.

SULKES: This seems to be a special plate which is basically a low efficiency plate, and I'm sure there's a reason why you are using it. But it does appear to be special. I wonder if you could explain some of the rationale behind it.

rms 67

HENNIGAN: We asked the supplier to build the batteries for synchronous orbit. They contacted ESB, and this is their recommendation, is that right, Gus?

CHREITZBERG: I'm not sure what you mean by low efficiency. This plate should operate at the C rate at .28 ampere hours per gram minimum. And here I think we're specifying at .25.

Now, if you go above .28 ampere hours per gram, then you would have to specify the separator system and electrolyte concentration and so forth.

SULKES: The specifications as it calls out is four -- over four grams per ampere hour as the test is here. That's what I was questioning. In other words, you're asking for 2.1 ampere hours. On an 8.8 gram plate, if you're talking about 2-1/2 grams per ampere hour, you should be getting somewhere like 3-1/2 ampere hours out of that plate. So, I'm only questioning the capacity in this 331.

CHREITZBERG: I think that's a very good point. It should be increased. We have a lot of slop there.

HENNIGAN: That was /before we requested all the positive plates be made from one lot of silver and one mix batch to be run and documentation be available to the purchaser.

For environmental requirements this was not imposed on the manufacturer necessarily. It was to give them some idea how we're going to use the cells. I kind of feel that the 100°F is too high if we want three-year life. If we flew this type of mission we would ask, as we do in the sil-cad area, zero to 25 or 30°C.

And then we specify the potassium hydroxide. We will use 40 percent. We call out the drawing and that they will measure to the drawing and that all the data will be supplied to Goddard.

The same way on the weights of grids, these so-called biscuits and plates is also to be supplied to Goddard, and the rejects are also to be -- we're supposed to know how many are rejected. Did you have a question?

COHN: No, but I have a comment. I notice on the drawing that you have one of those tremendous wires leading off that plate. Have you considered putting a tab on there instead of a wire to get better current distribution and maybe longer life and perhaps also have less trouble with kinking and splitting and so forth, getting a better bonding of the tab to the plate, instead of this small wire.

STEINHAUER: This is a tab.

COHN: It looks like a wire.

STEINHAUER: It is 10 mils thick and 60 mils wide. It's a ribbon.

COHN: What's the width of the plate?

STEINHAUER: About the -- the whole plate?

COHN: Yes.

STEINHAUER: Two inches.

COHN: About two inches?

STEINHAUER: The plate itself?

COHN: Yes.

STEINHAUER: Two inches.

COHN: Have you considered using a tab about an inch or an inch and a half wide?

STEINHAUER: It's not really necessary in this application for the discharge currents that we expect it to carry. This is quite adequate.

COHN: You're going to use a very low rate of discharge and a very low rate of charge?

STEINHAUER: Yes, it is designed for about C rate discharge.

COHN: For the C rate?

STEINHAUER: Yes.

COHN: Have you ever measured the plate with a full width tab and a plate with this kind of tab to see whether you can find differences in temperature distribution?

STEINHAUER: We have not.

COHN: I suggest you might do that sometime. If you operate them at the C rate, there's a good possibility that there will be an effect of the width of the tab and

rms 70

that you would gain in performance and in life by having a decent width of tab that is somewhere near the full width or however close you can get of the width of the plate rather than this bit of wire there.

RICHARDSON: With these types of wires or narrow tabs, we've experienced breakage during vibration testing with this type of arrangement. And you wind up with a reduced capacity in your cells when you break several wires. Now, with the wider tabs we haven't experienced this problem during vibration testing.

HENNIGAN: Well, this is similar to the ones we have in the sil-cad battery. It's a tab of this type. As far as I know, we've never broken a tab. We have had trouble with the integrity of the tab weld to the silver. As we've said before, the check is to pull it and make sure you've destroyed the plate before you pull the tab off.

STEINHAUER: In this batter design where these plates will be incorporated, the cell core or cell stack is not free to move. In other words, those tabs are not expected to be flexed during vibration.

RICHARDSON: When you get a cell pack like that, you can't make it too tight. Even in tight cells packs you can get movement of the plate stack within the cell jar.

STEINHAUER: Yes. On a normally constructed cell

rms 71

this makes use of separator frames. We have eliminated the U-fold. These frames are epoxied within the case, so that this whole stack is rigidized.

RICHARDSON: That's one way that I think you can possibly restrain the pack movement.

CHREITZBERG: The problem is certainly not as simple as going from wires to the screen. If you have a problem of cell pack design to a given vibration requirement such that the cell pack itself moves, it is a matter of time before the screen will break.

If you design properly, you can pass a vibration spec with either screen or wires. So, this is certainly a part of it, but not the entire picture. I think it is correct that you should have that amount of silver in the tab which will give you the proper conductivity and proper distribution.

From my experience the distribution of current is going to be a function of the screen inside the plate as well as the tab leading to the plate, especially at high states of charge.

And here the one zero grid might not be adequate to properly distribute it at high current rates.

FLEISCHER: I think this cell has one plate, one silver plate?

HENNIGAN: No, six.

rms 72

FLEISCHER: Six. Then the 2.2 ampere hours is the capacity of the plate itself -- one plate?

STEINHAUER: One plate.

FLEISCHER: WEll, the C rate on that, the discharge in your lead wire amounts to about 3000 amps per square inche cross-sectional area, and I think this is nominal for silver leads.

HENNIGAN: What was that number again?

FLEISCHER: It calculates out to -- if you calculate the cross-sectional area of this lead, the 2.2 amperes is roughly 3000 amperes per square inch, which is a nominal high rate discharge for silver.

HENNIGAN: This has to do with Ernst's remark about current density.

HENNIGAN: We will go on/the chemical section here, the silver powder. At this time we accept the receiving inspection of the manufacturer with a certificate of performance, the same as we do with the grid. Packaging was specified. This was rather a -- it wasn't so bad on the silverplate, but it's pretty hard to ship a dry silver oxide cell around. But this was specified so we would have some control on the packaging.

Identification is pretty standard here. There were some quality assurance provisions and inspection controls by theseller, GFC(?) through D-CAS and what to do

rms 73

with rejected assemblies.

I guess this sounds pretty boring, but this is about where we started with the sil-cad spec about five years ago, and if you keep working at it,eventually we might have a silver zinc spec similar to the sil-cad spec. I hope we don't have to tie it in so much to one supplier.

On the other one, the zinc oxide, the first page is -- or the first two paragraphs are essentially the same as the silver spec. In general here, we call out for a teflonated, unformed 5.5 ampere hour zinc oxide plate. It does say here the cell will have six positive and seven negatives.

Under paragraph 3.1, the physical requirements are given. And later on we specify that the 100 percent inspection should be done. And the composition of the zinc oxide mix is also given here.

SULKES: In view of some of the reports of the effectiveness of the extended edge plates, you don't allow the zinc to get smaller than the positive by toler-ancing, perhaps it should be toleranced such that the zinc should always be bigger.

In other words, rathere than allowing 2.940 minus -- in other words, only let it go on the plus side. And this way you'll always assure that your zinc is somewhat larger than your positive electrode.

rms 74

HENNIGAN: WEll, we have some additional work being done where the zinc will be larger, about an eighth of an inch, would that sound about right?

SULKES: Well, an eighth is certainly fine, but even just by spec tolerances you can at least assure that you're getting, oh, 30 or 60 mils at a minimum.

HENNIGAN: Well, the grid is called out. Now, on this particular grid they did have a fold-back at the edges to strengthen the edge. Would that be to also have better adherence of the zinc oxide at that area?

STEINHAUEP: It was felt that that would support the zinc oxide at the edge. Since that time where we've actually operated cells with this, we are somewhat concerned in that the EXMET with that fold-back thickness is about 35 mils when this is a 29-mil thick plate, so that you have EXMET right at the edge of the zinc oxide material around the periphery.

We may be running into some incipient short problems because of this fold-back. And we mav have some afterthoughts on using this fold-back.

HENNIGAN: All right.

And the silver tab is spelled out here. Also on the other plates 100 percent inspection with lot plots of the entire plate lot with the low, normal and high values and their spread given on an X plus or minus some percent.

The density of the zinc oxide is also spelled out. It is 49 grams per cubic inch.

GREEN: Green, Martin.

I notice that you give the plot plates on the negative here, but you don't define any method of assembly like you do on the silver plates in the other specification. Any reason for that?

HENNIGAN: Any method of assembly?

GREEN: Yes, if you will look over in the other one, you make the statement that, "Make sandwiches using one grid and two nominal db sheets or one H and one L db sheet, allowing them assembly." But you do not do this in this other plate. Is there any reason for that.

HENNIGAN: Do you want to answer that, Gus?

CHREITZBERG: The processes are completely different. The description of the manufacture of the cadmium plate is very similar to the manufacture of the zinc plate here. We don't make two sheets and put them on either side of a grid in this case, so it is not described.

HENNIGAN: The plate electrical connection is spelled out here which is also shown on the drawing attached. The tab is called out to be attached to the silver grid in this case rather than in the silver case where we attach it to the silver center(?). And we ask for optimum weld process conditions. That turned out to be a pull test, if

rms 76

I remember right.

The EXMET grid is also called out as far as purity and weight per square inch.

On the chemical requirements the zinc oxide powder should be A.C.S. reagent grade. We didn't know at the time what the particle size should be so we asked the manufacturer to at least measure it,and we had the data. And we requested to have the data sent to us. The mercuric oxide use is also A.C.S. grade, and it is two percent of the total mix.

The teflon powder is not specified too closely here. It is Teflon 7, but we asked for some process controls that the manufacturer normally does to be performed.

The silver EXMET grid is also specified in the next paragraph.

The electrical requirements as far as capacity, the current density which we intend to use the cell at, and the depth of discharge of the cell is spelled out. It gives the manufacturer some idea how we intend to use these plates.

FLEISCHER: Tom, I want to go back to the teflon. As I recall, when the matter of the teflon carbon platinum black electrodes for fuel cells was discussed, it was very definitely brought out that one of the problems in making these things had been that teflon had a wetting

rms 77

agent in it. And this wetting agent apparently was changed from time to time without notifying anybody. In fact I don't think anybody really knew there was one in it, so here you are now going to introduce one of the things that's been bothering us. And you had no control indicated.

HENNIGAN: At this time I don't know if we can get enough information from duPont to control it. Could you guess?

CHREITZBERG: As far as I know there is no wetting agent.

SULKES: In some cases duPont 30, which I assume is similar, all these particles do have a wetting agent, however they are removed by a heat process. And I don't know if ESB is using it in this case. But if there would be one, there is no control on it as to temperature, time and so on.

Also control -- let's say uniformity of teflon dispersion, because in mixing these things you can get conglomerates and so on which you do want to avoid. So, I would say that the overall quality of the plate is left pretty much up to the manufacturer. You don't have too many controls on it, as perhaps you should be having.

HENNIGAN: As I mentioned before, this is a first cut at this thing. And it took us many years to get the other one out which is not perfect, and we feel it will

rms 78

take a few years to straighten this one out. You have to find out an awful lot of information over the years to write these types of specifications.

CHREITZBERG: One comment on the wetting agent. Teflon 30 is a mixture in a liquid, Teflon 7 is a dry powder. Teflon 30 requires a wetting agent for dispersion. Teflon 7, the dry powder, does not.

HENNIGAN: In the next paragraph on quality requirements, the usual 100 percent sampling is required to measure plate thickness, height and width. EXMET-type grid weight. Total plate weight and active mix weight by difference. Again this information is requested to be sent to the purchaser. Here they can't mix enough for this lot of cells, so we have to buy off on more mixed batches, but the powder is to be from the same lot. And again documentation is requested on this lot.

In the environmental requirements, again the temperature is specified as 30 to 100 degrees F. And if we would use these type of cells, we would like to keep that at zero to 25 or 30° C.

And the plates should be optimum in 40 percent KOH.

Under physical tests. This just requires that they meet the drawing and that the EXMET type grids and so forth and completed plates would be weighed, 100 percent

rms 79

inspection also required.

On this zinc oxide we would accept the conformance to the receiving lot inspection analysis and a certificate of conformance to the lot. If you remember, these were A.C.S. grades.

Also for the mercuric oxide which is also A.C.S. On the chemical -- at least receiving lot analysis of the EXMET grid.

As far as preparation for delivery, I have some afterthoughts about shipping plates, dry silver oxide plates, that's a very difficult thing to do. And it probably would be better to -- Well, I don't know how we would do it the next time. This time they had to be hand-carried. WE'll have to figure that one out. They are quite fragile.

As far as identification, the usual information we want on the order and on the boxes that they come in.

And quality assurance provisions are essentially the same as before with government inspection and also data on the rejected assemblies.

And this last paragraph was put in by the plate manufacturer.

Well, as I say, these are pretty rough at this stage of the game. We would like to come up with a specification on silver zinc batteries as far as process type controls and material type controls that's a little more comparable to what we have on the sil-cad battery.

Does anybody have any general comments or questions?

SULKES: I would say these are a good first try, but really they are extremely specific to one particular battery. I think there's at least enough information to make a first stab at a general spec with individual technical specification sheets for each specific electrode.

In other words, a lot of these processes are general and could be in a -- let's call it a basic boilerplate,and you would just add on a few sheets to determine the specific electrode and not have to go over and redo a spec every time. Plus I think it would be helpful for other manufacturers. This one tends to be specific for only one. I think this would apply also to the sil-cad.

HENNIGAN: Do you want to help us on that, Martin?

(No response.)

Any more questions or general comments about the sil-cad or the silver zinc.

If not, it is 12:00. I think it is a good time to break. We are not going to adjourn this afternoon. We have to give up this room at 1:00. I certainly thank you all for coming. I know some of you came from quite a distance.

rms 81

And I hope you enjoyed this rather unusual meeting. I think it was a little different from the meetings you go to.

I think people were pretty open. There are certain steps in the processes that the companies have to respect. And If we know them, we have to respect the company.

So, thank you again very much for your attention.

(Whereupon, at 12:04 p.m., the meeting was concluded.)

R.N.W Blanket

Transcript of Proceedings

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS

Building Number 3
Goddard Space Flight Center
Greenbelt, Maryland

Friday, 31 October 1969

[redacted]

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